4-16

INITIAL PLANNING ANALYSIS OF SELECTED MID-LATERAL RESERVOIR SITES

Imperial Irrigation District
Water Resources Unit
September 1997

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1.0 INTRODUCTION

Within the Imperial Irrigation District (District), mid-lateral reservoirs would serve primarily to reduce lateral operational discharges and possibly reduce tailwater. These reservoirs would be constructed one-half to two-thirds of the way down a lateral and would have approximately 30 acre-feet of storage area. The reservoir would be constructed parallel and adjacent to the channel, or formed within an existing lateral by widening and deepening a section of the channel to serve as a collector pool. This would allow excess flows to be stored within the lateral and used to supply deliveries downstream. Mid-lateral reservoirs would also function to reduce lateral fluctuations and increase delivery reliability.

From 1987 to 1992, the District's average annual lateral discharge averaged 115,000 acre-feet. ("On-Farm Irrigation Efficiency, Boyle Engineering, 1993) The Plum-Oasis lateral interceptor project is estimated to have conserved 5,680 acre-feet of lateral discharge. The Mulberry-D and Trifolium interceptors are estimated to save 5,950 and 11,200 acre-feet, respectively. Thus, an estimated 22,800 acre-feet of this discharge has been conserved, leaving approximately 92,200 acre-feet of losses available for further conservation. The District has no experience with mid-lateral reservoirs, therefore water conservation is unknown. However, an analysis of the District's delivery records for selected laterals indicates that 60 percent of lateral discharge might be conserved. One way to improve this estimate is to build a mid-lateral reservoir in a test program, similar to the initial test programs that evaluated 12-hour deliveries and tailwater return systems.

A mid-lateral reservoir project might require that a landowner take land out of production, but in exchange would allow water users the ability to turn water back to the lateral simply by notifying the District prior to their action. District operating rules would need to be modified for this project to allow the water users these cut-back opportunities and to define the conditions under which they would be allowed. Mid-lateral reservoirs could also require changes to District operations as additional zanjeros or night patrolmen may be needed to adjust gates when the water users turn water back.

1.1 INITIAL SITES

Initial sites chosen for evaluation were selected by Water Department Management Team. Management's site list included Acacia Canal at Lateral 4 Heading, Acacia Canal at Lateral 6 Heading, Alder Canal at Lateral 7 Heading, Elder Canal at Elm Canal Heading, Eucalyptus Canal at Ebony Heading, Hemlock Canal at Lateral 4 Heading, and a connecting reservoir at Fisher Road between the Woodbine and Wormwood Canals. Holtville Division staff suggested Hemlock Canal at Lateral 2B Heading as a site. Zanjeros suggested East Highline Lateral 1 and Mesa Lateral 3 Spill as a potential site.

Upon further review with division staff, the Acacia Canal at Acacia Lateral 4 was dropped from consideration. Acacia Lateral 4 spills in the Rose Canal; Zanjeros stated that there is more spill at Acacia Lateral 6. Also dropped was the Hemlock Canal at Hemlock Lateral 2B. Hemlock Lateral 4 is more of a problem to keep on order than Hemlock Lateral 2B. The entire Hemlock Canal has capacity problems due to a capacity restriction near the heading at Highway 98 and Hemlock Delivery 5.

1.2 EVALUATION CRITERIA

Evaluation criteria included:

a) cost (gravity in and gravity out flow preferred)
b) number of 12-hour deliveries upstream and downstream of the site,
c) daily deliveries
d) length of lateral
e) unsteadiness (estimated by Division Operations Staff), and
f) lateral discharge volume, if known.

Evaluation criteria for gravity in and gravity out flow is located in Appendix A. Appendix B contains evaluation criteria for unsteadiness. As a result of using the criteria in Appendix A and B, three sites are selected for further evaluation.

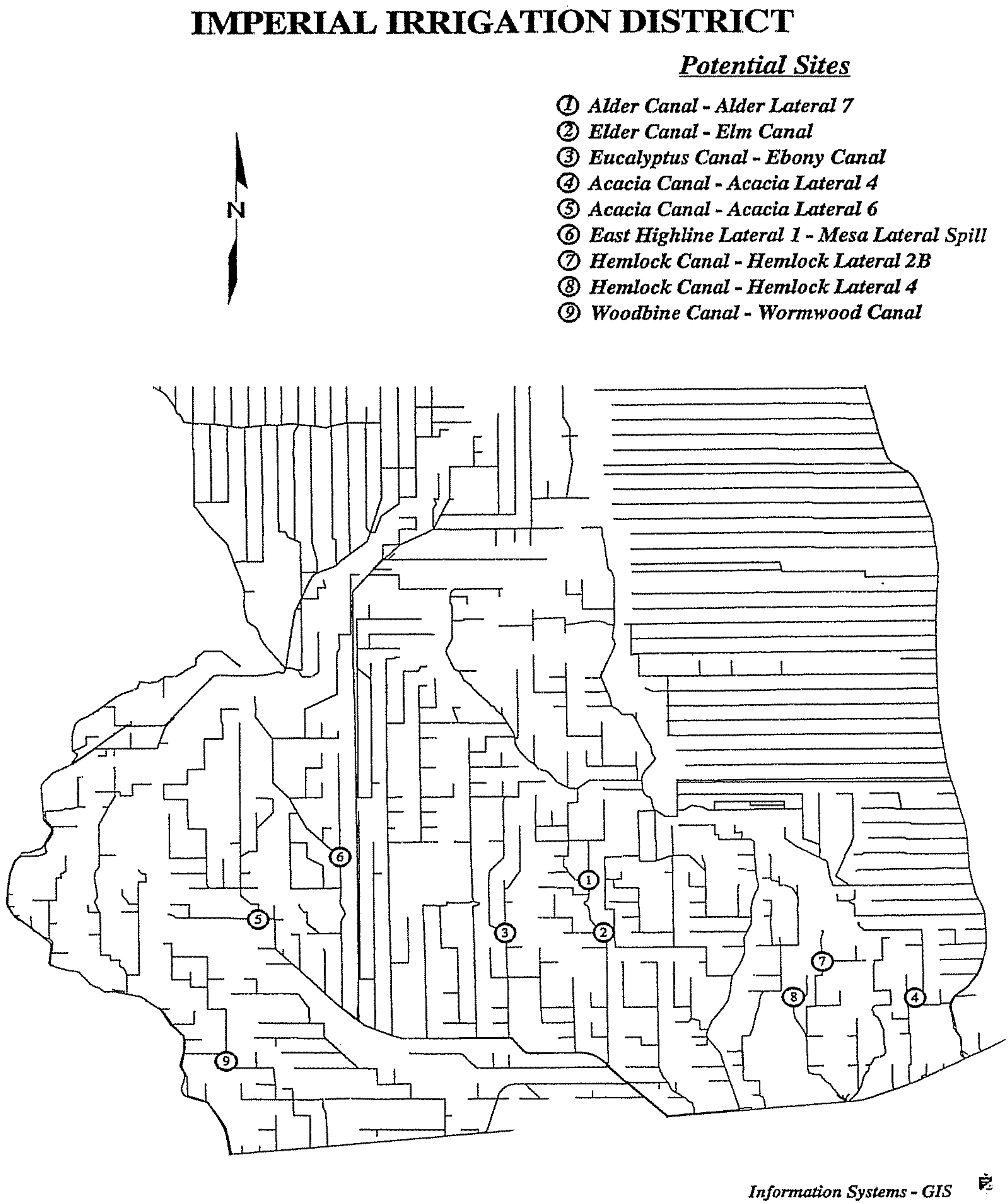


Figure 1: Mid-Lateral Reservoir Site Locations

2.0 POTENTIAL MID-LATERAL RESERVOIR SITE SETTINGS

2.1 ALDER CANAL - ALDER LATERAL 7 SITE

This is the only site evaluated where a reservoir could gravity flow water in and out. Between Alder Delivery 82/Lateral 7 check and Alder Delivery 83 the change in high water elevation is 7.6 feet over a distance of 3,075 feet. Appendix A contains elevation data.

The reservoir site is triangular in shape and located on the south and west sides of the Alder Canal. The reservoir would be adjacent to Alder Canal starting at the check for Alder Delivery 82 (also deliveries 47 and 48) and ending at Alder Delivery 81. A pipeline would gravity the outflow to the downstream side of the check for Alder Delivery 83. Reservoir outflow for Alder Lateral 7 will be taken out at the lateral heading. Refer to Figure 1 for reservoir location, Figure 2 for reservoir layout, and Figure 3 and 4 for reservoir site views.

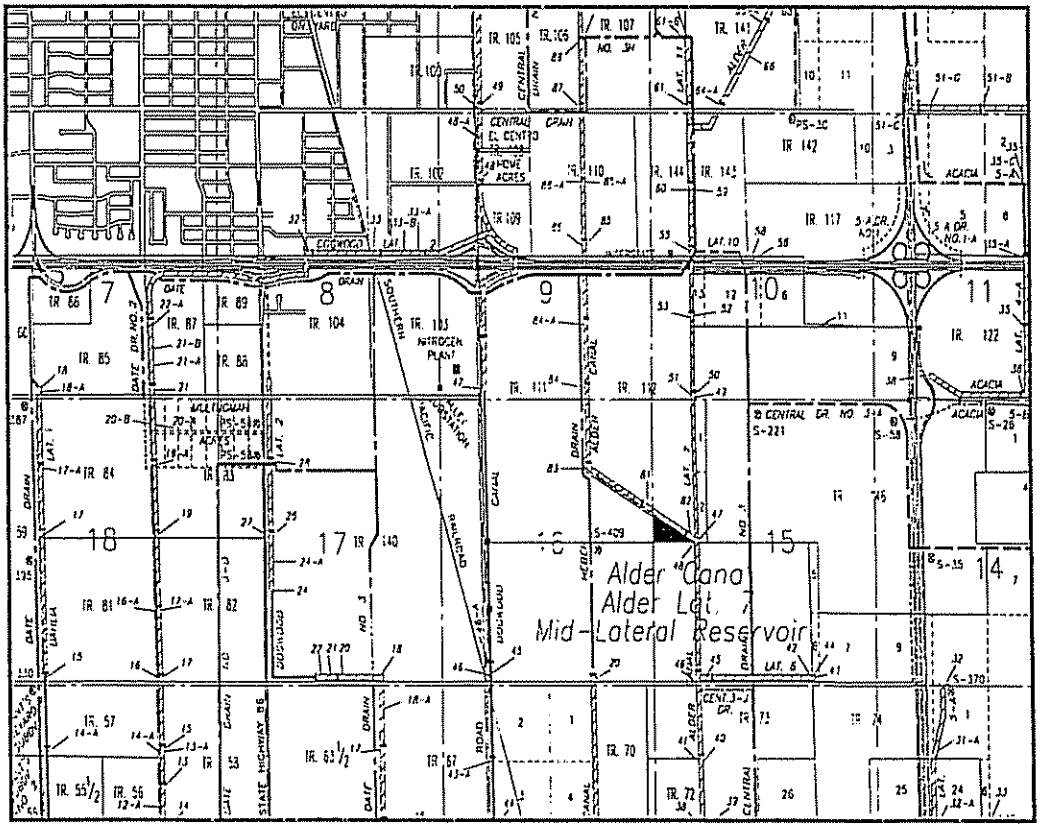


Figure 2: Alder Canal - Alder Lateral 7 Reservoir Layout

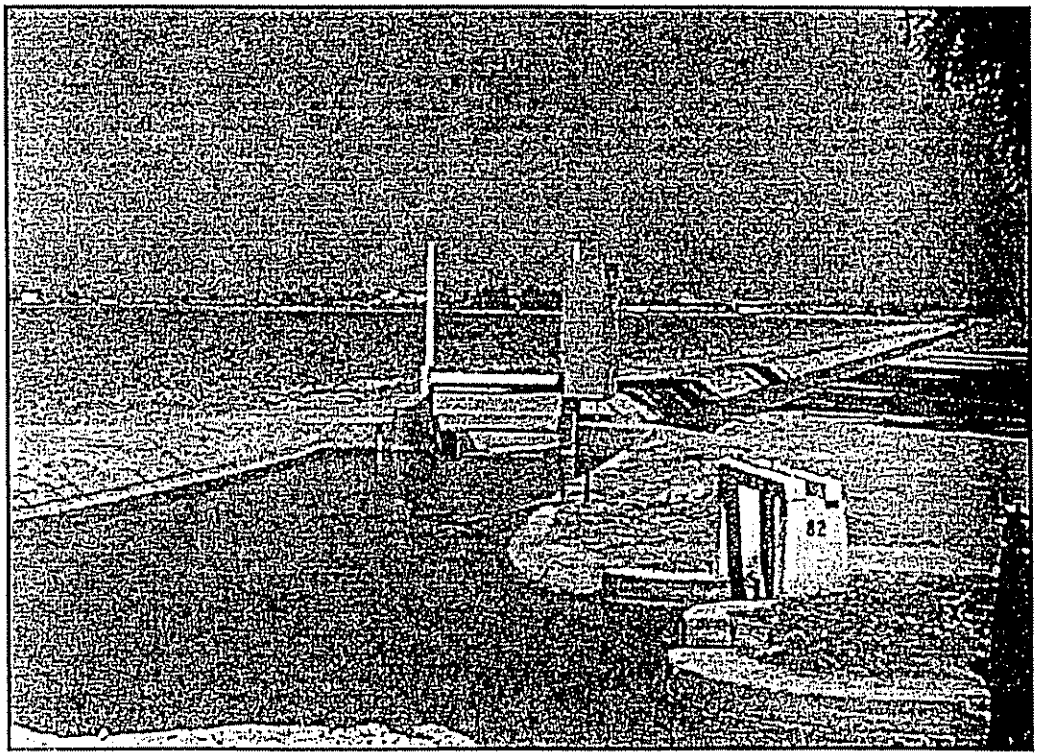


Figure 3: Alder Canal-Lateral 7 Reservoir Site; Alder Delivery 82, Looking West, Reservoir Site on Left

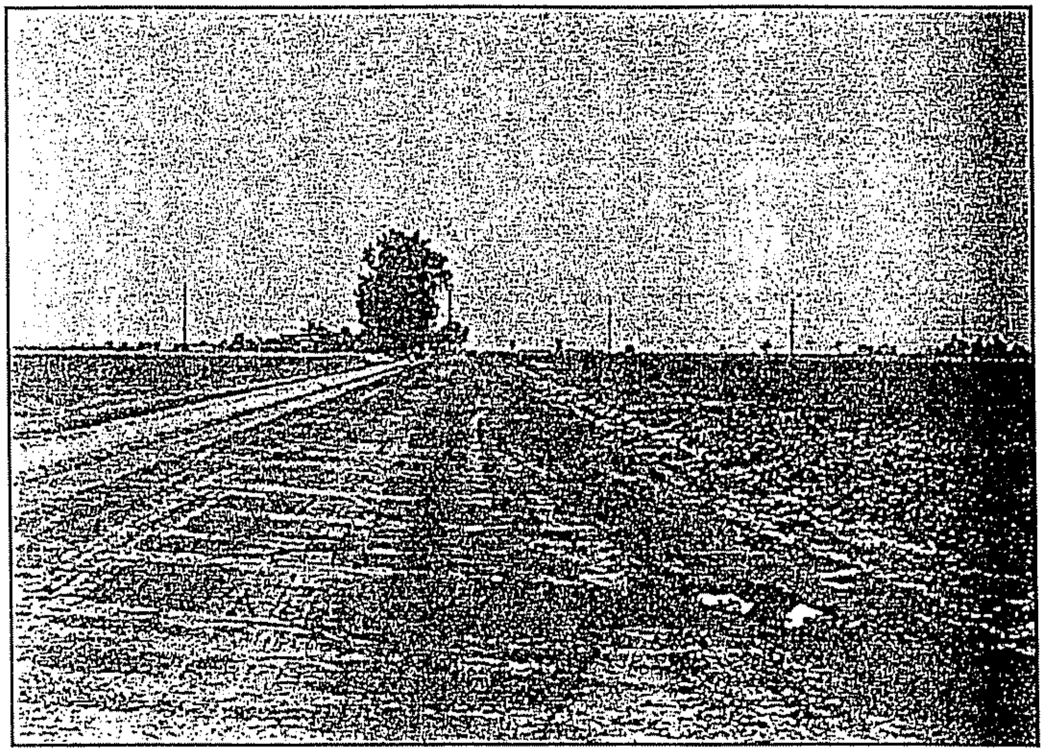


Figure 4: Alder Canal Site; Alder Canal Upstream Delivery 81; Looking Southeast, Reservoir Site on Right

As indicated in the following charts (Figures 5 through 12), the Alder Canal had 451 12-hour runs in 1996 with an average 12-hour head of 1.8 cfs. From May 1986 through April 1997 the maximum daily delivery for the Alder Canal was 264.1 cfs and the maximum 12-hour daily delivery was 21.4 cfs. From May 1986 through April 1997 the maximum daily delivery for the Alder Canal downstream Delivery 48 was 77.5 cfs and the maximum 12-hour daily delivery was 12.3 cfs. The daily deliveries and the percentage of delivery days information is included in Figures 5 through 8 for Alder Canal and Figures 9 through 12 for deliveries downstream Alder Delivery 48/Alder Lateral 7.

Alder Lateral 7 is estimated as unsteady by the zanjero. There are a number of service pipes along Alder Lateral 7. Appendix B contains unsteadiness estimates and Appendix C contains spill data. Alder Lateral 7 is approximately 3.6 miles in length.

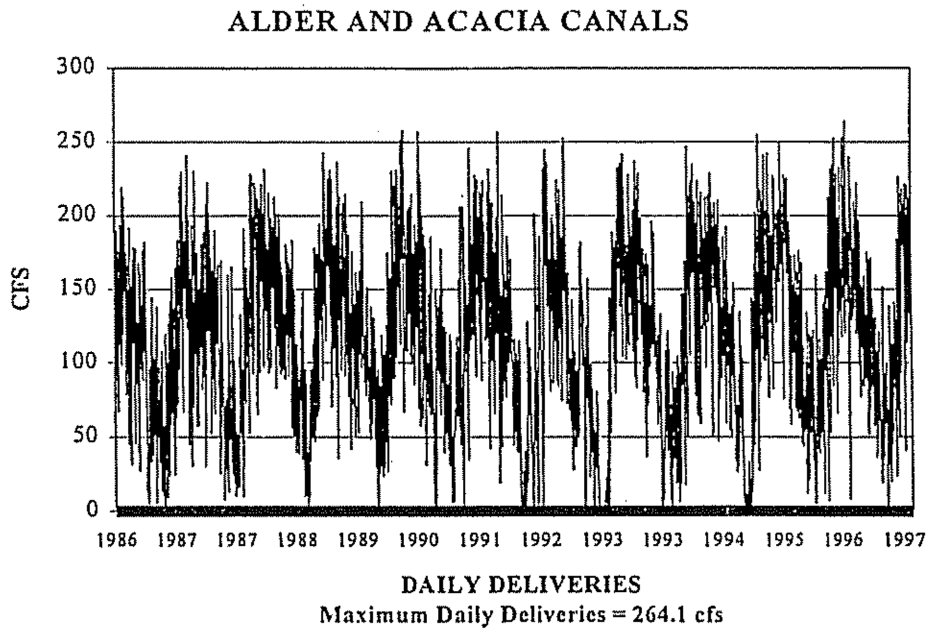


Figure 5: Alder Canal Heading Daily Deliveries

ALDER AND ACACIA CANALS

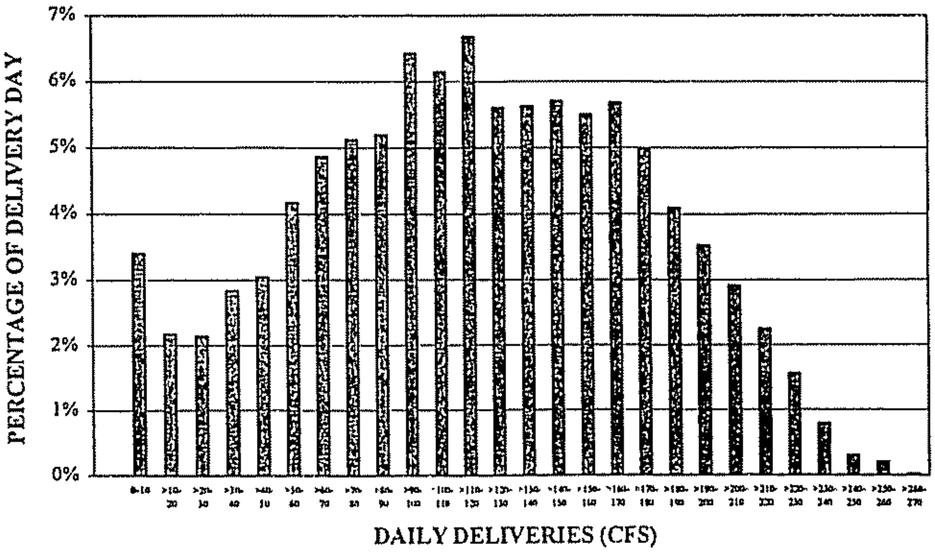
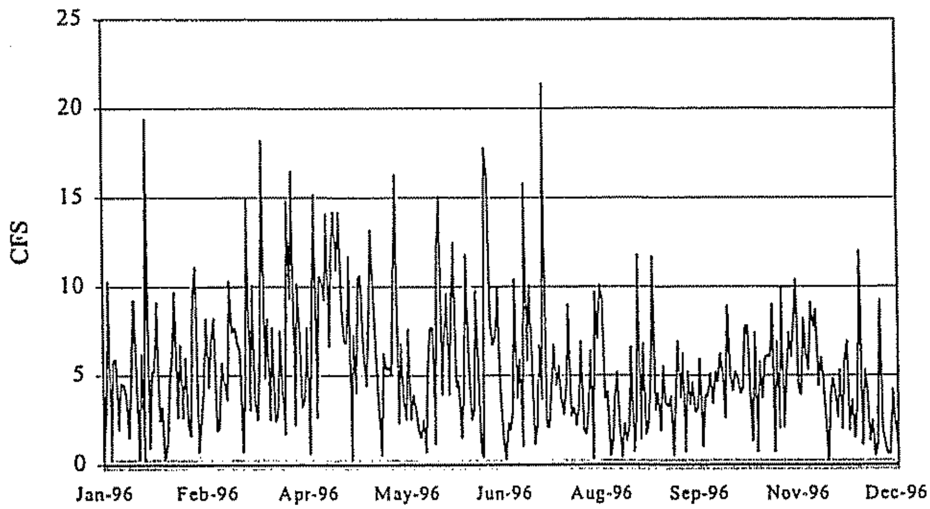


Figure 6: Alder Canal Heading Percentage of Delivery Days

ALDER AND ACACIA CANALS



12-HOUR DAILY DELIVERIES
Maximum 12-Hour Daily Deliveries = 21.4 cfs

Figure 7: Alder Canal Heading 12-Hour Daily Deliveries

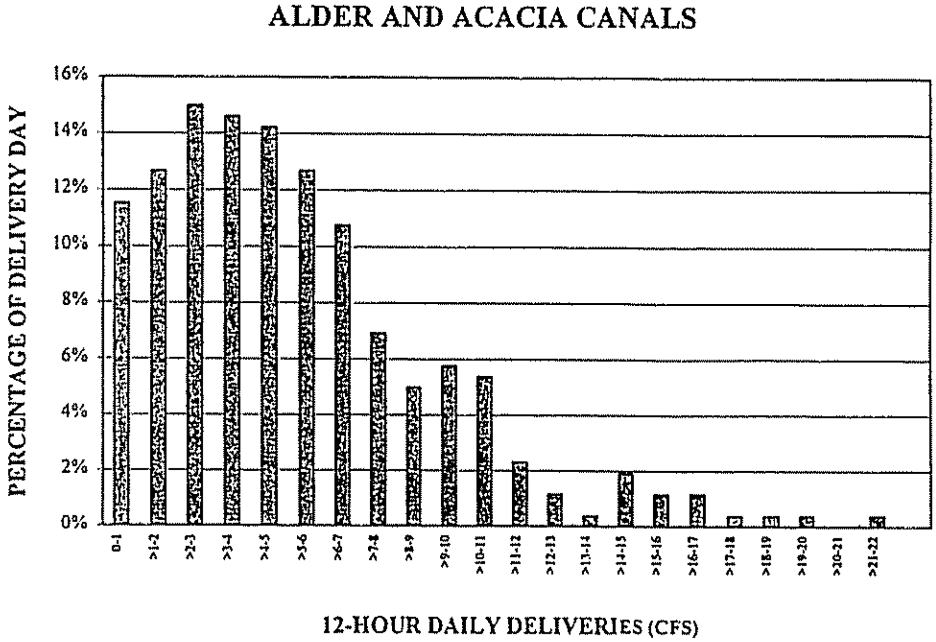


Figure 8: Alder Canal Heading 12-Hour Percentage of Delivery Days

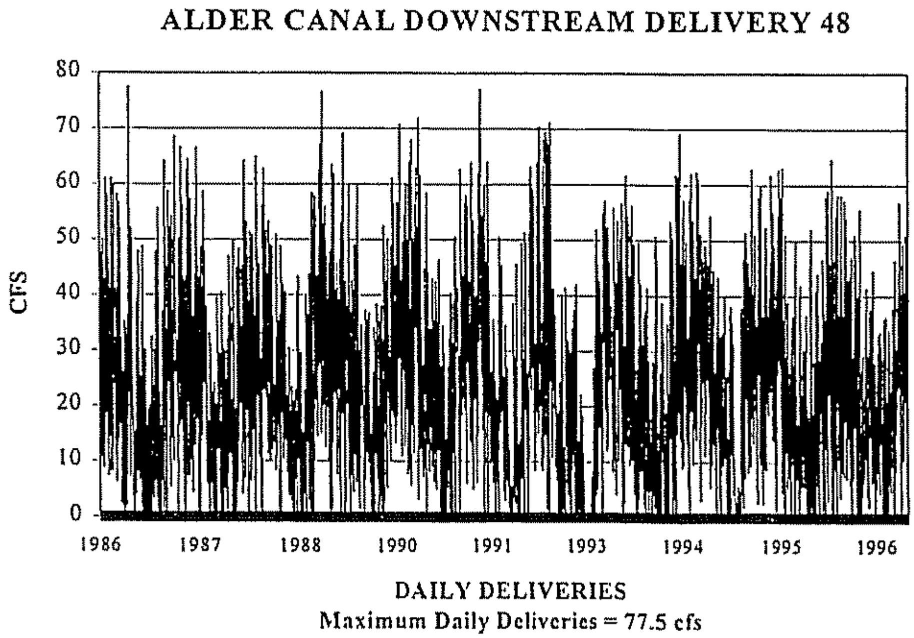


Figure 9: Alder Canal Downstream Delivery 48 Daily Deliveries

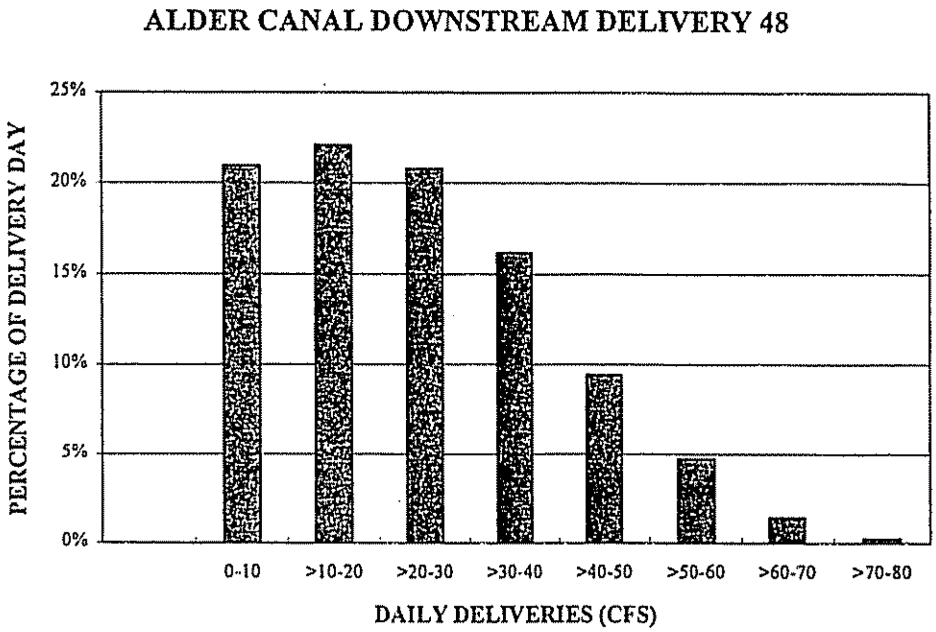


Figure 10: Alder Canal Downstream Delivery 48 Percentage of Delivery Days

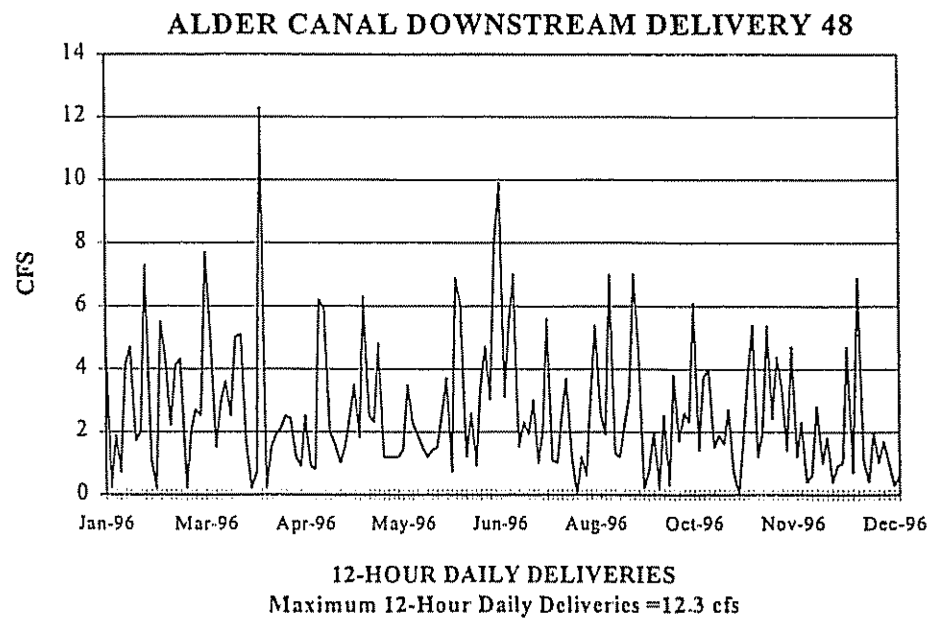


Figure 11: Alder Canal Downstream Delivery 48, 12-Hour Daily Deliveries

ALDER CANAL DOWNSTREAM DELIVERY 48

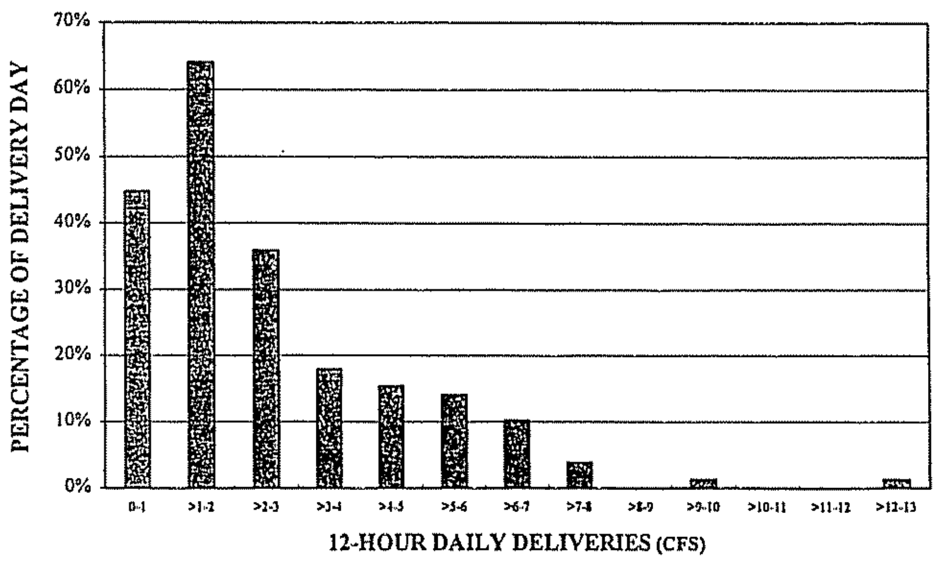


Figure 12: Alder Canal Downstream Delivery 48, 12-Hour Percentage of Delivery Days

The Alder Canal - Alder Lateral 7 site has been selected as a potential site for a mid-lateral reservoir.

The Alder Canal - Alder Lateral 7 reservoir would have no annual power cost associated with it due to the gravity flow of water in and out of the reservoir. The costs associated with a three foot deep 30 acre-foot reservoir include:

- Pond Construction	\$ 96,750
- Pipe and Installation	\$ 31,300
- Structure and Measuring Devices	\$ 37,750
- Total Cost	\$165,800
- Annualized Capital Cost (8%, 35 years)	\$ 14,226

Appendix D contains data for cost estimates.

2.2 ELDER CANAL - ELM CANAL

A reservoir at this site could gravity flow into the reservoir but would have to pump out. The reservoir site's field grade runs opposite to the canal grade. Between Elder Delivery 77/Elm Canal/Elm Lateral 1 check and Elder Delivery 82/83 check the change in elevation is 3.2 feet for the high-water and -0.6 feet for the natural surface over a distance of 2,814 feet.

A reservoir would be a narrow rectangle shape. It would be located on the north side of Elder Canal and on the west side of Elm Canal. The reservoir would be adjacent to the Elder Canal starting at the check for Elder Delivery 77/ Elm Canal Heading and ending at the check for Elder Lateral 10, Elder Delivery 82, and Elder Delivery 83. Reservoir outflow would be directed into the Elder Canal downstream of the check for Elder Lateral 10 Heading. Refer to Figure 1 for reservoir location, Figure 13 for the reservoir layout, and Figures 14 through 16 for the reservoir site views. Figure15 shows the field site's reverse grade as compared to the Elder Canal slope.

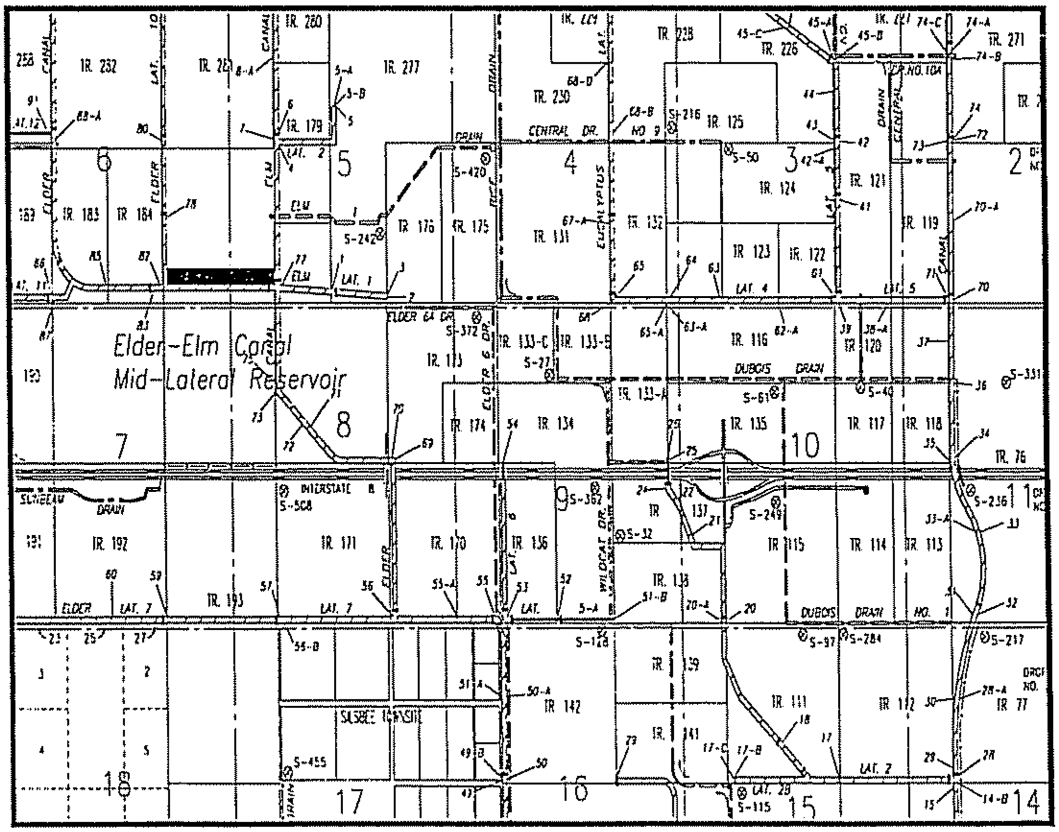


Figure 13: Elder - Elm Canal Reservoir Layout

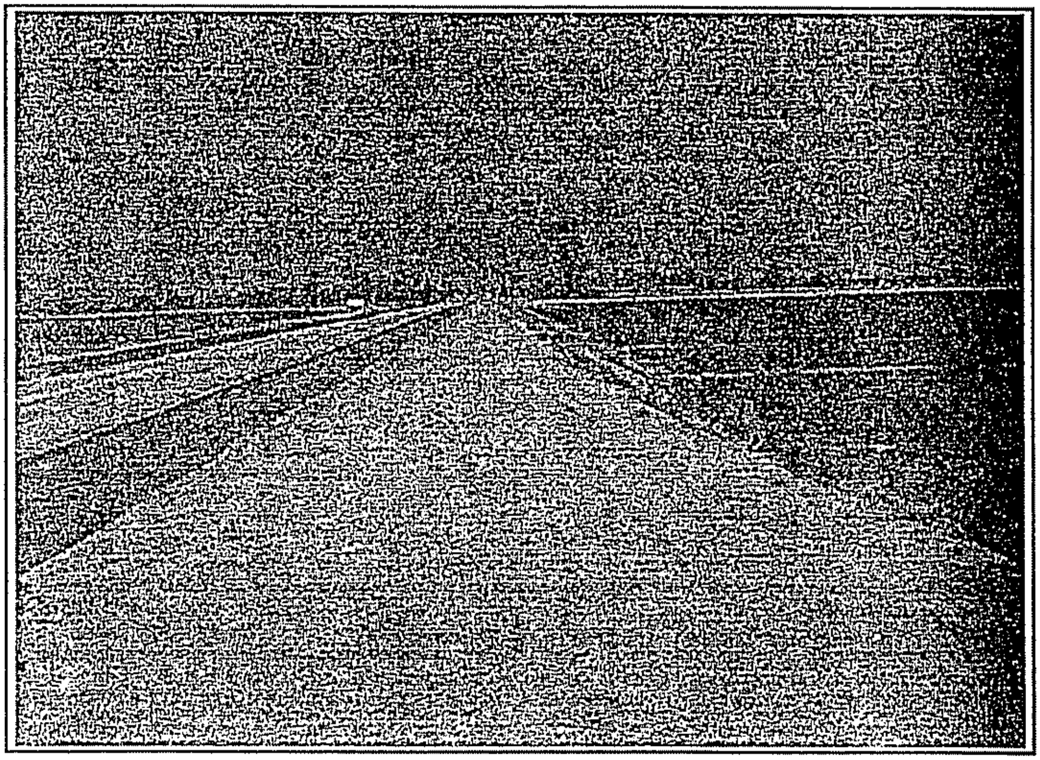


Figure 14: Elder-Elm Site; Elder Delivery 77, Looking West, Reservoir Site on Right

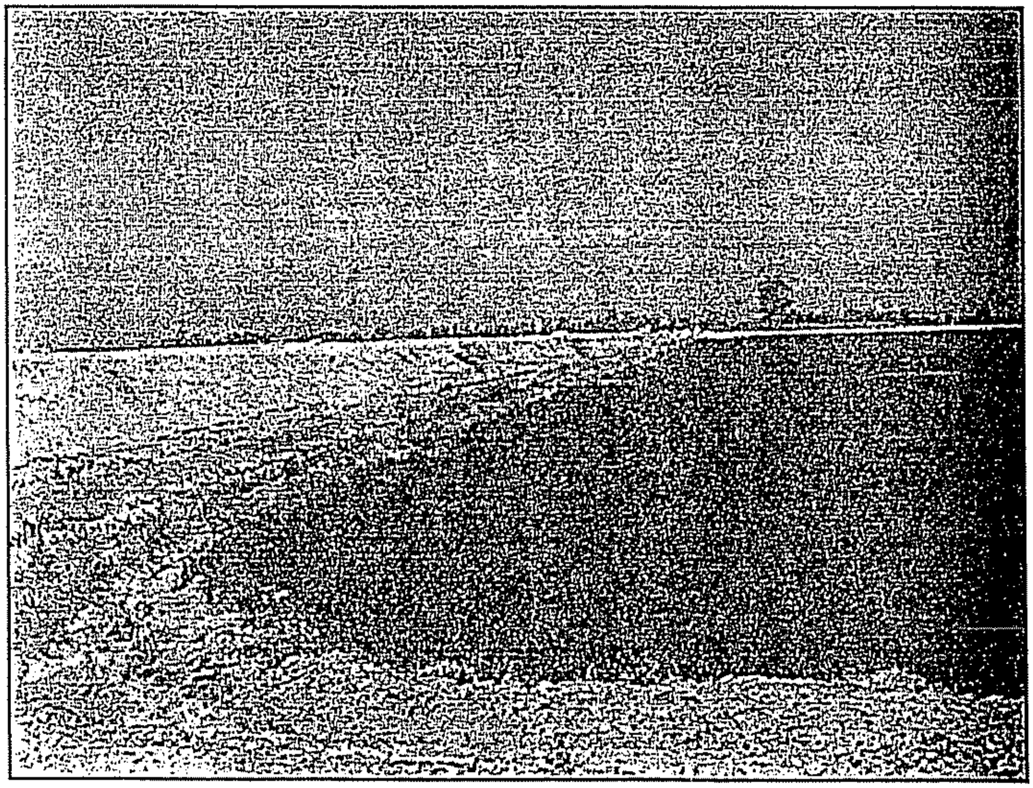


Figure 15: Elder-Elm Reservoir Site; Elder Delivery 77, Looking West, Reservoir Site on Right

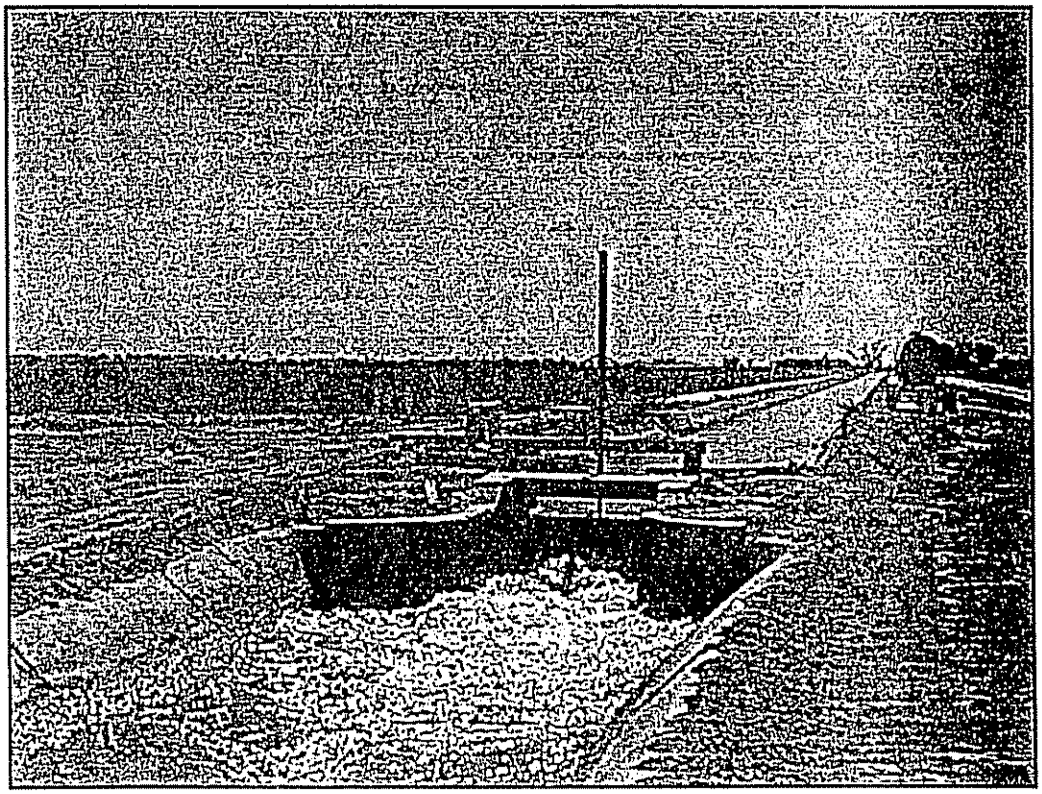


Figure 16: Elder-Elm Site; Elder Check for Delivery 82 & Lateral 10, Looking East, Reservoir Site on Left

As shown in the following charts, the Elder Canal had 499 12-hour runs in 1996 with an average 12-hour head of 2.6 cfs. From May 1986 through April 1997 the maximum daily delivery for the Elder Canal was 269.4 cfs and the maximum 12-hour daily delivery was 21.9 cfs. From May 1986 through April 1997 the maximum daily delivery for the Elder Canal downstream delivery 77 was 169 cfs and the maximum 12-hour delivery was 20.4 cfs. These daily deliveries and the percentage of delivery days information is included in Figures 17 through 20 for Elder Canal and Figures 21 through 24 for deliveries downstream Elder Delivery 77/ Elm Canal heading.

The Elder Canal is estimated as unsteady by the zanjero. A reservoir would cut travel time from four hours to two hours for deliveries located downstream of the reservoir. The Elm Canal is approximately 4.8 miles in length. The Elder Canal Spill was 2,075.3 ac-ft with a mean flow of 2.9 cfs for 1996. The Elm Canal spill was 1,522.1 ac-ft with a mean flow of 2.1 cfs in 1996. Appendix C contains spill data.

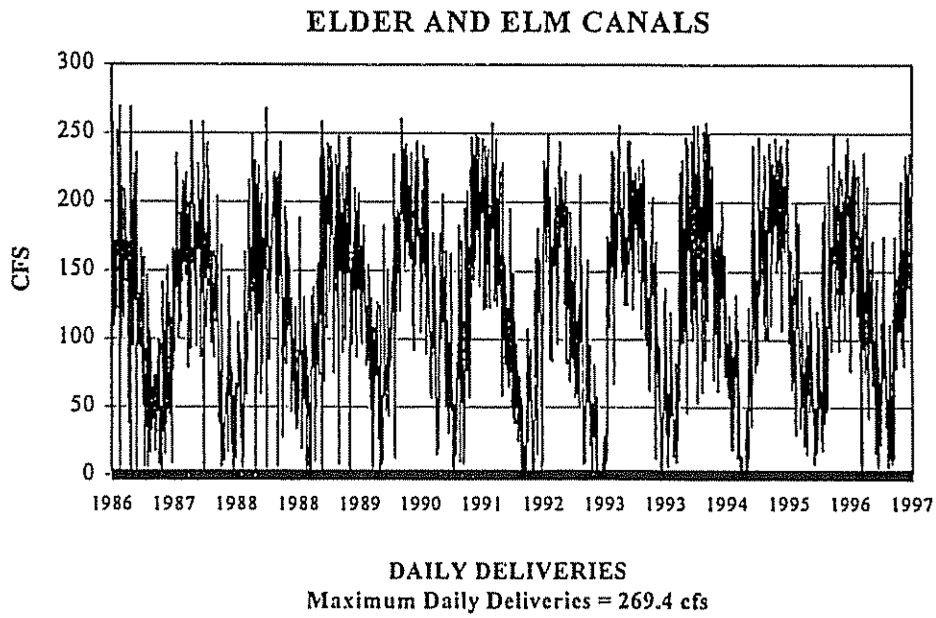


Figure 17: Elder Canal Heading Daily Deliveries

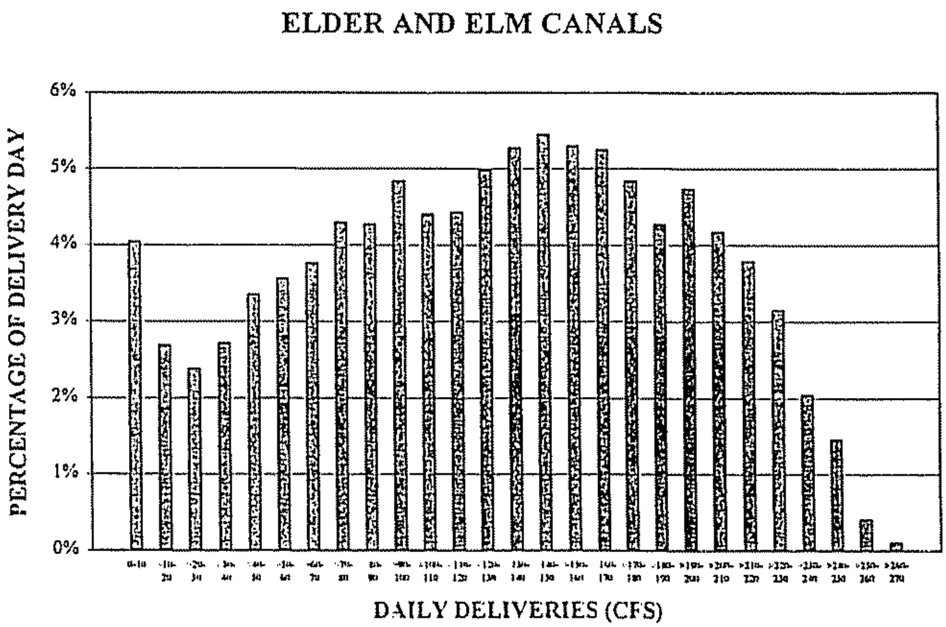
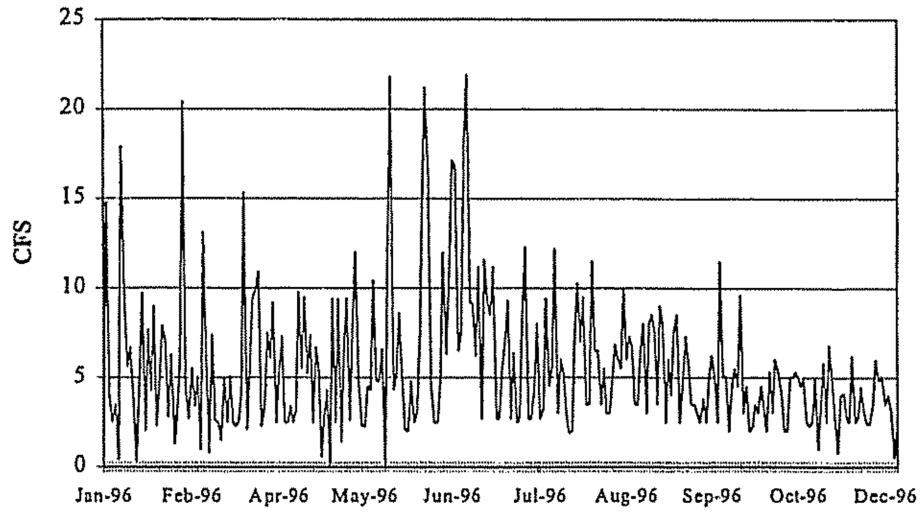


Figure 18: Elder Canal Heading Percentage of Delivery Days

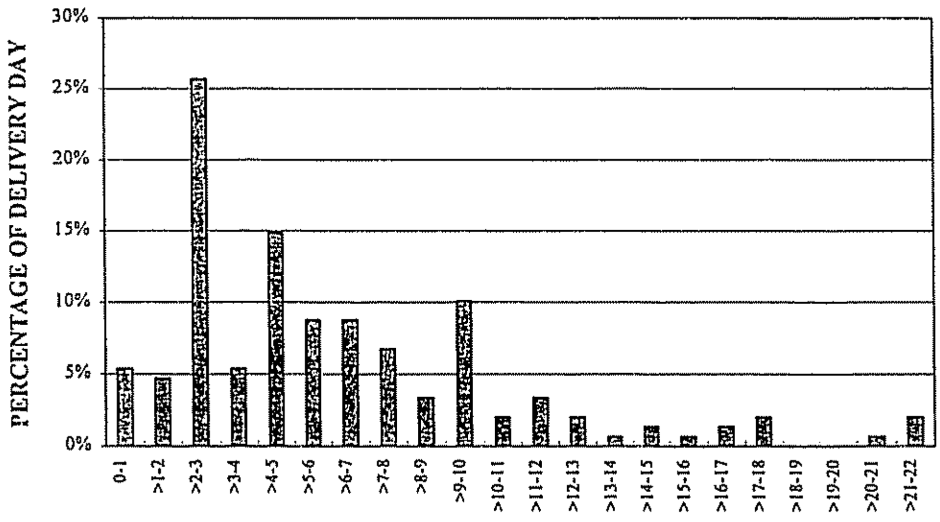
ELDER AND ELM CANALS



12-HOUR DAILY DELIVERIES
Maximum 12-Hour Daily Deliveries = 21.9 cfs

Figure 19: Elder Canal Heading 12-Hour Daily Deliveries

ELDER AND ELM CANALS



12-HOUR DAILY DELIVERIES (CFS)

Figure 20: Elder Canal Heading 12-Hour Percentage of Delivery Days

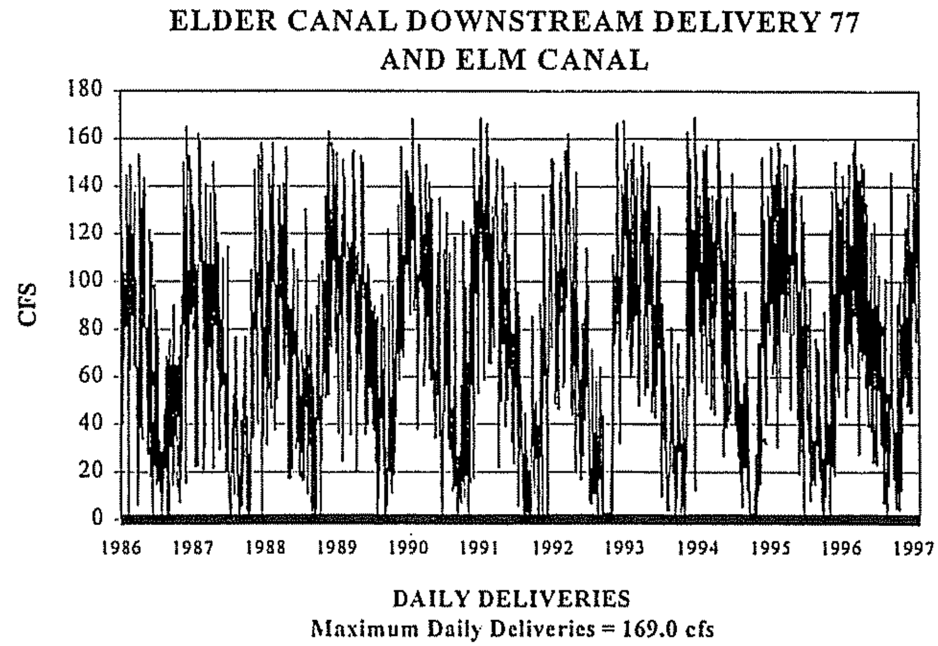


Figure 21: Elder Canal Downstream Delivery 77 Daily Deliveries

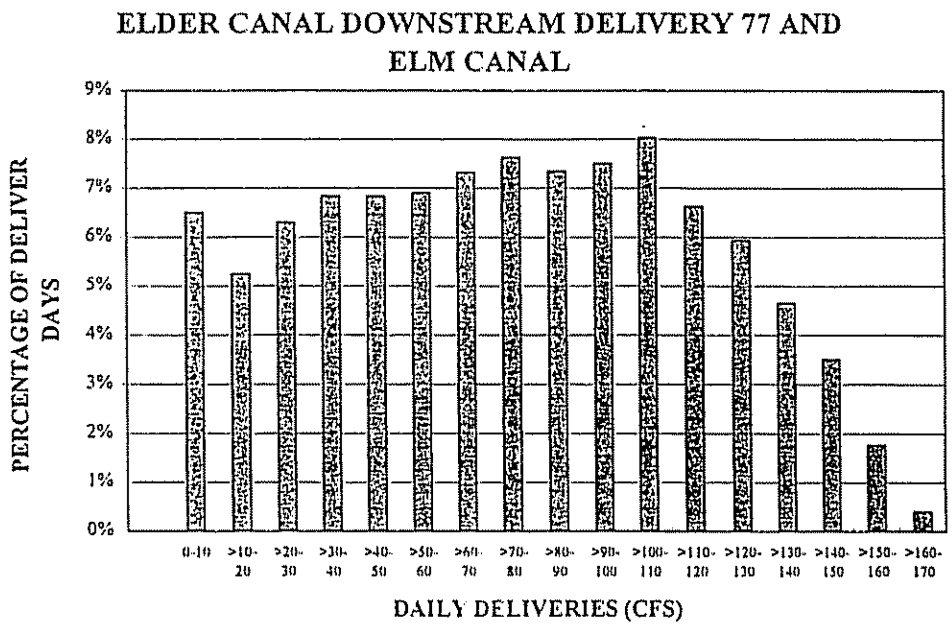


Figure 22: Elder Canal Downstream Delivery 77 Percentage of Delivery Days

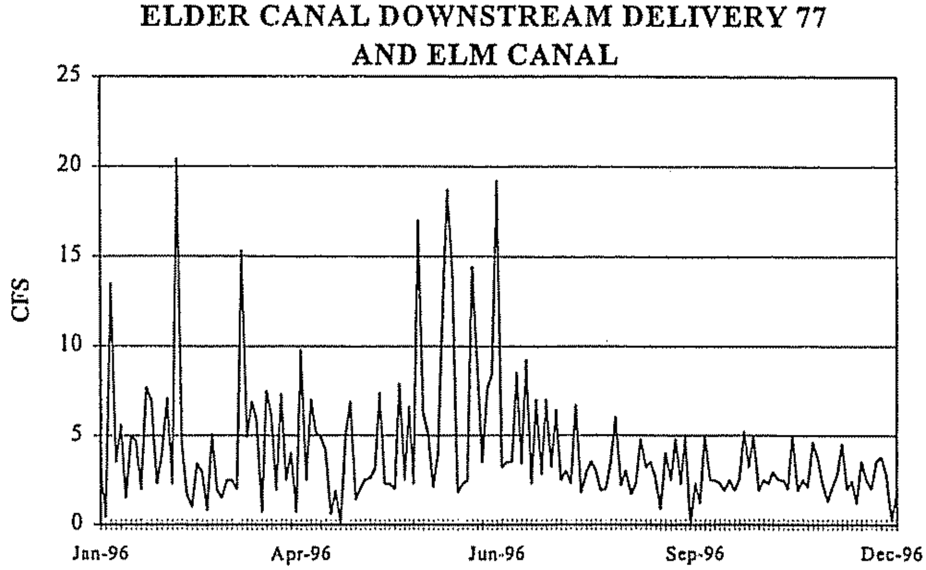


Figure 23: Elder Canal Downstream Delivery 77, 12-Hour Daily Deliveries

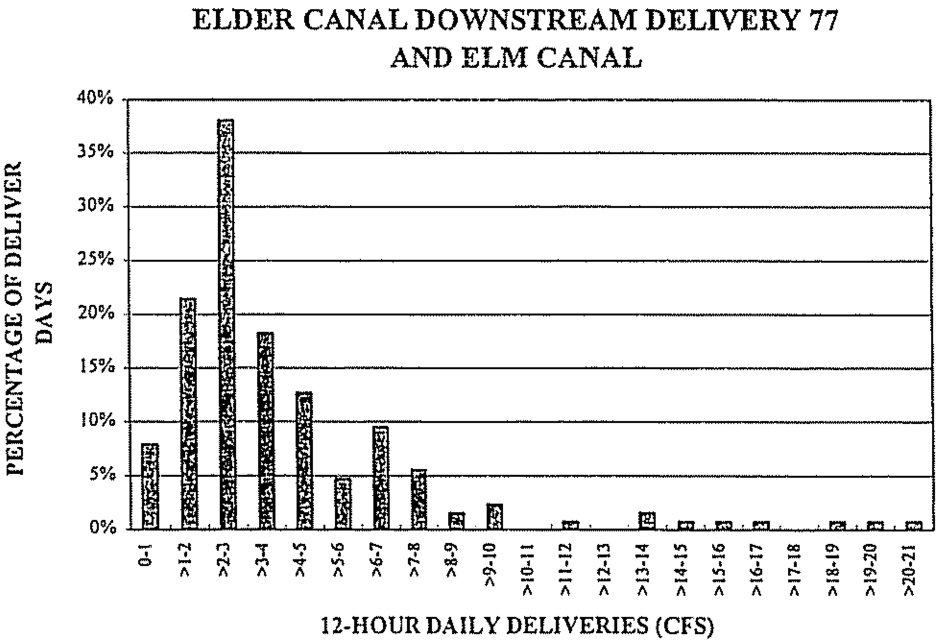


Figure 24: Elder Canal Downstream Delivery 77, 12-Hour Percentage of Delivery Days

The Elder Canal - Elm Canal reservoir would have an estimated annual power cost of $5,780. The cost associated with a four foot deep 40 acre-foot reservoir include:

- Pond Construction	$125,450
- Pump and Installation	$ 20,800
- Structure and Measuring Devices	$ 37,750
- Total Cost	$184,000
- Annual Capital Cost (8%, 35 years)	$ 15,787
- Annual Power Cost	$ 5,780
- Total Annual Cost	$ 21,567

Appendix D contains data for cost estimates.

2.3 EUCALYPTUS CANAL - EBONY CANAL

A reservoir at this site could gravity flow into the reservoir but would have to pump out. The reservoir site's natural surface does not have a sufficient drop in elevation to gravity flow out of the reservoir. Between Eucalyptus Delivery 77 and Eucalyptus Delivery 77A check the change in elevation is 3.0 feet for the high-water and 3.0 feet for the natural surface over 2,210 feet.

The reservoir site is a triangular shape. It would be located on the north side of the Eucalyptus Canal and on the west side of the Ebony Canal. The reservoir would be adjacent to the Eucalyptus Canal starting at the check for Eucalyptus Delivery 77 / Ebony Canal Heading and ending upstream from Eucalyptus Delivery 77A. Reservoir outflow would be directed to the Eucalyptus Canal near Eucalyptus Delivery 77A. Refer to Figure 1 for reservoir location, Figure 25 for the reservoir layout, and Figures 26 and 27 for the reservoir site views.

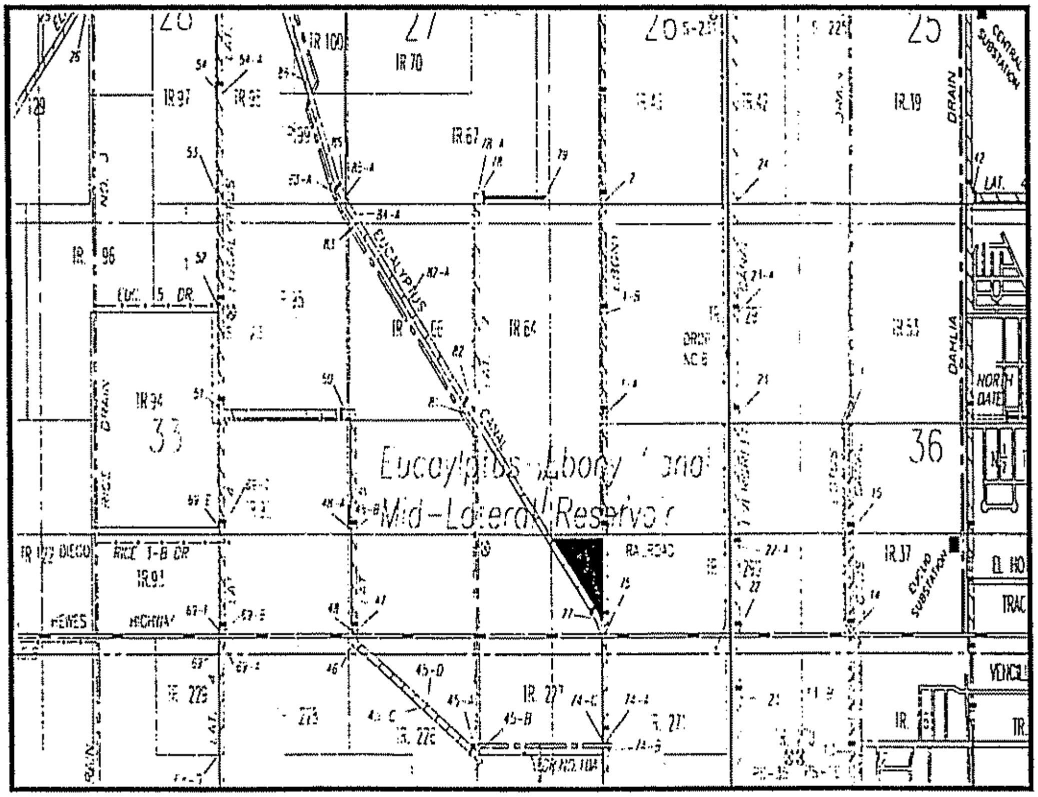


Figure 25: Eucalyptus - Ebony Canal Reservoir Layout

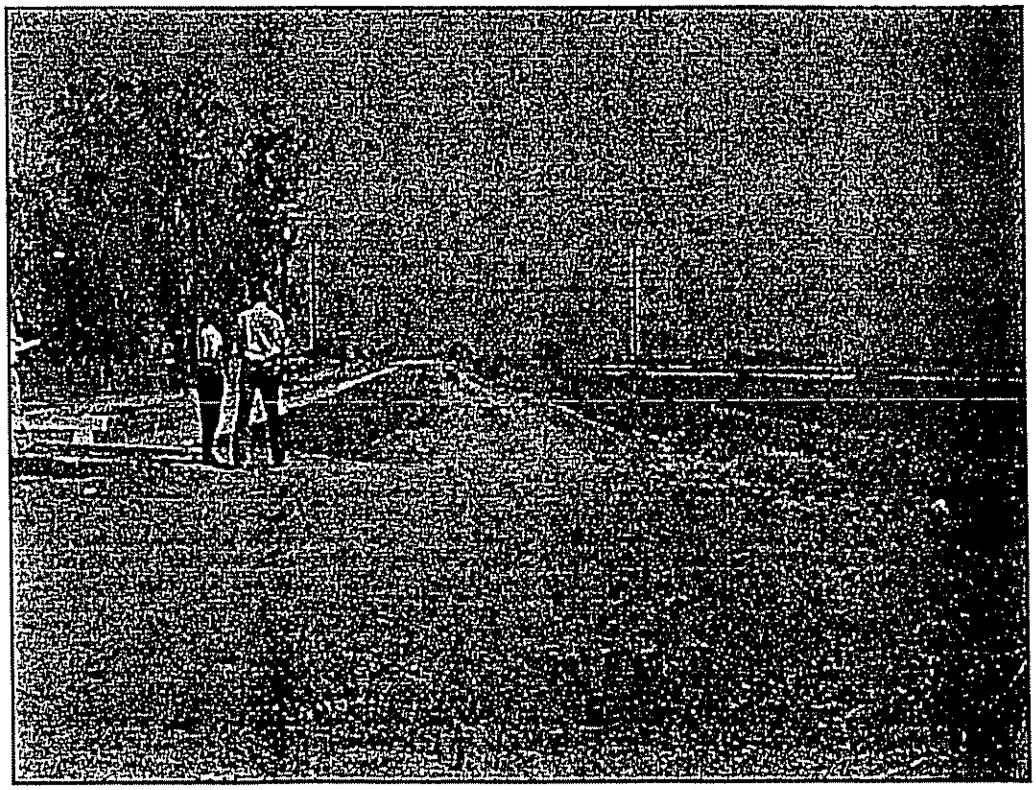


Figure 26: Eucalyptus-Ebony Site; Eucalyptus Delivery 77, Looking Northwest, Reservoir Site on Right

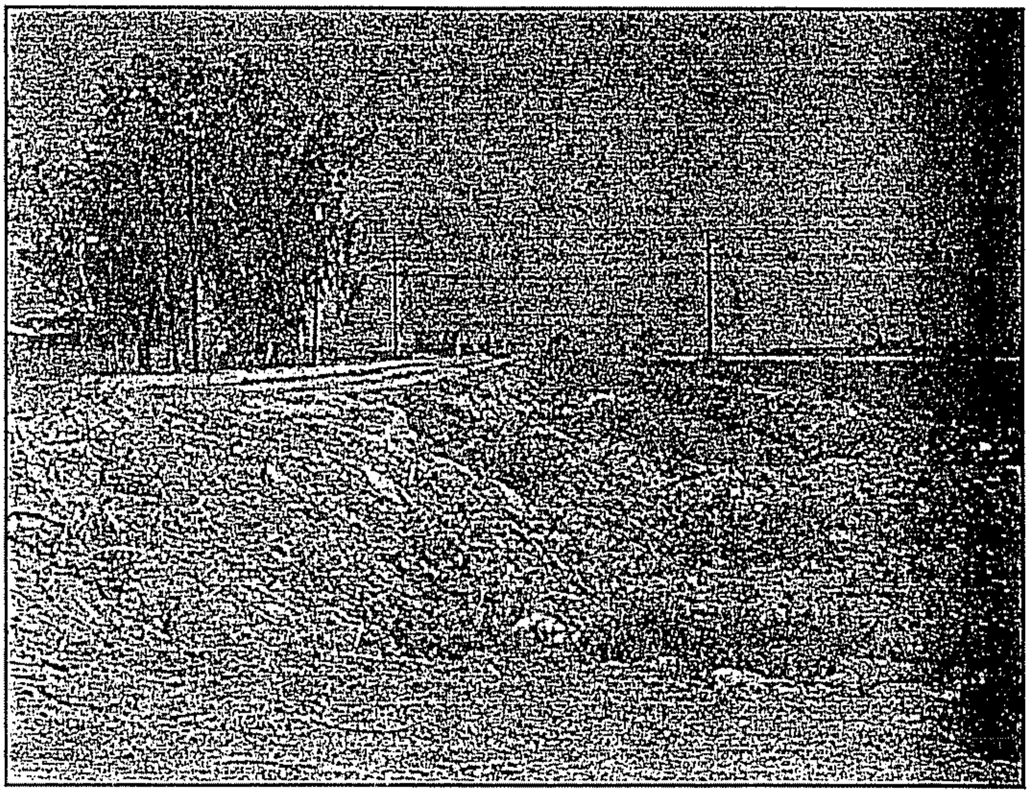


Figure 27: Eucalyptus-Ebony Site; Looking Northwest, Reservoir Site on Right, Field Grade View

As indicated in the following charts (Figures 28 through 35), the Eucalyptus Canal had 624 12-hour runs in 1996 with an average 12-hour head of 2.2 cfs. From May 1986 through April 1997 the maximum daily delivery for the Eucalyptus Canal was 256.9 cfs and the maximum 12-hour daily delivery was 20 cfs. From May 1986 through April 1997 the maximum daily delivery for the Eucalyptus Canal downstream delivery 77 was 166.6 cfs and the maximum 12-hour daily delivery was 17.2 cfs. These daily deliveries and the percentage of delivery days information is included in Figures 28 through 31 for Eucalyptus Canal and Figures 32 through 35 for deliveries downstream Eucalyptus Delivery 77/Ebony Canal Heading.

The Eucalyptus Canal is estimated as unsteady at night by the zanjero. The canal has several fields of sprinkler irrigated vegetables which increases the unsteadiness. The Eucalyptus Canal is approximately 3.1 miles in length. The Eucalyptus Canal spill was 678 ac-ft with a mean flow of 0.9 cfs for 1996. The Ebony Canal spill is estimated as 202 ac-ft with a mean flow of 0.3 cfs in 1996. Appendix B contains unsteadiness estimates and Appendix C contains spill data.

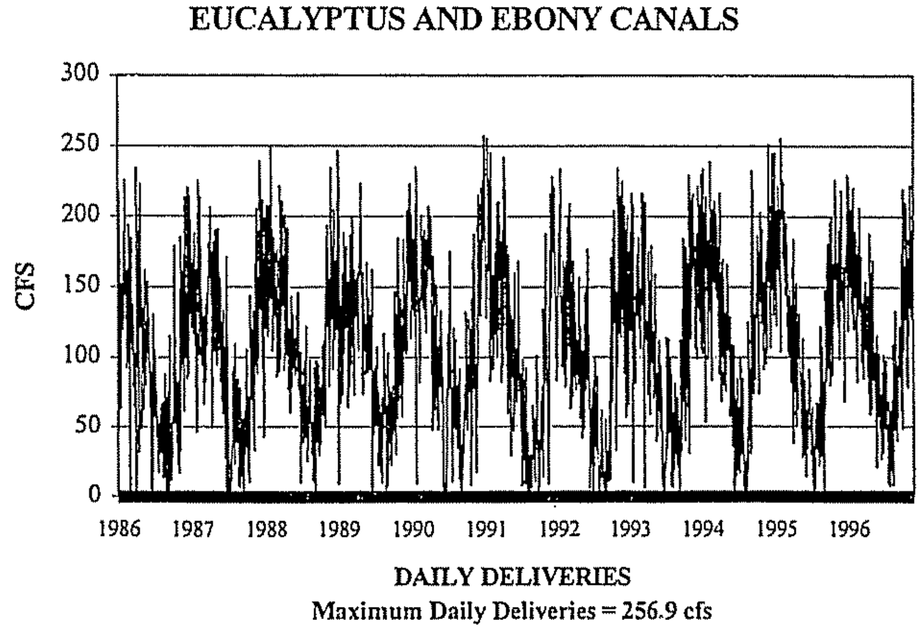


Figure 28: Eucalyptus Canal Heading Daily Deliveries

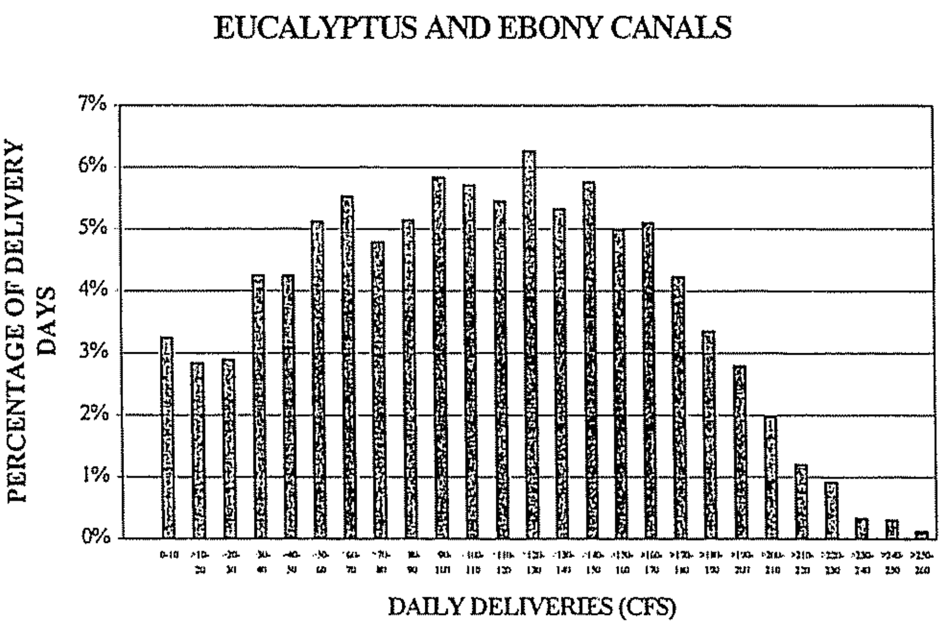


Figure 29: Eucalyptus Canal Heading Percentage of Delivery Days

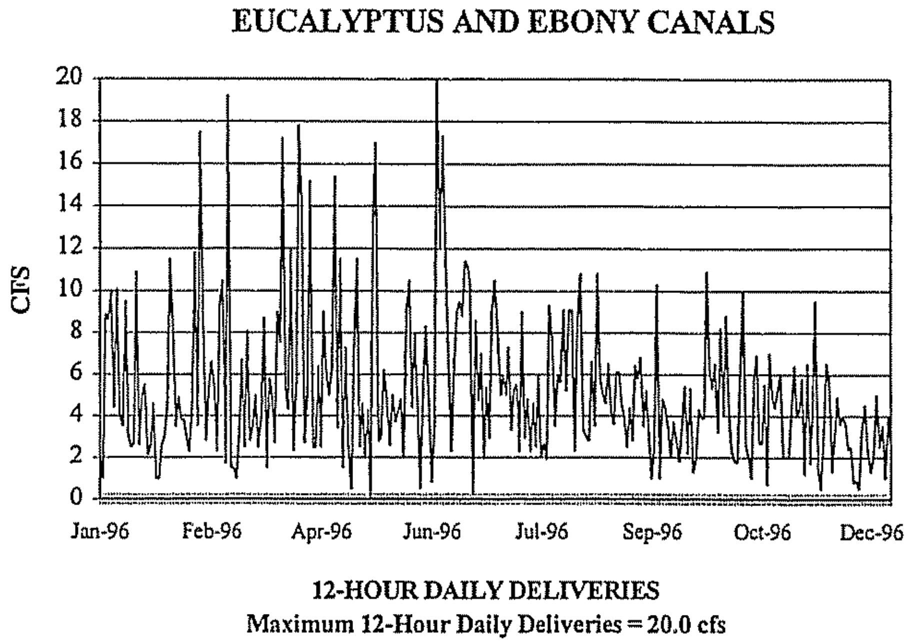


Figure 30: Eucalyptus Canal Heading 12-Hour Daily Deliveries

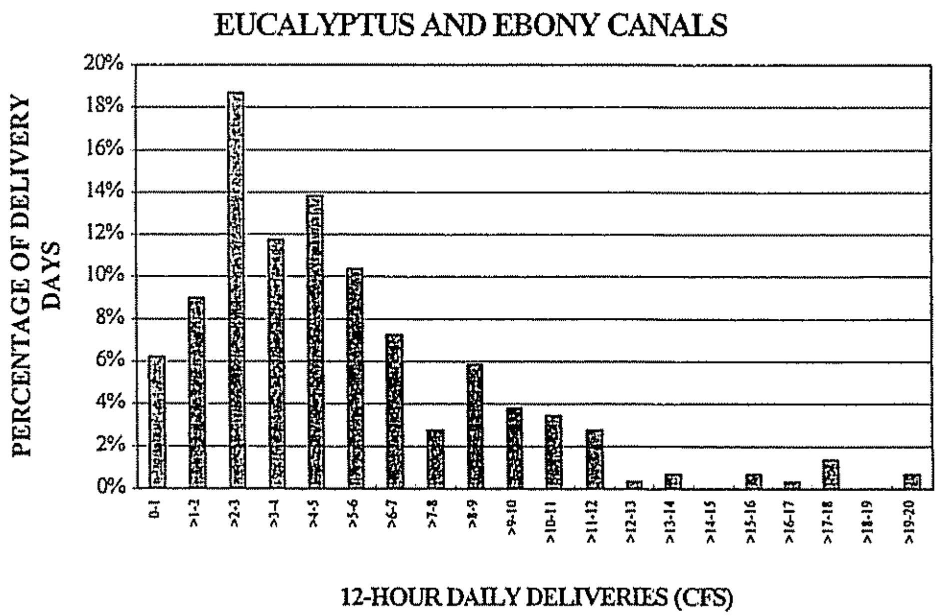


Figure 31: Eucalyptus Canal Heading 12-Hour Percentage of Delivery Days

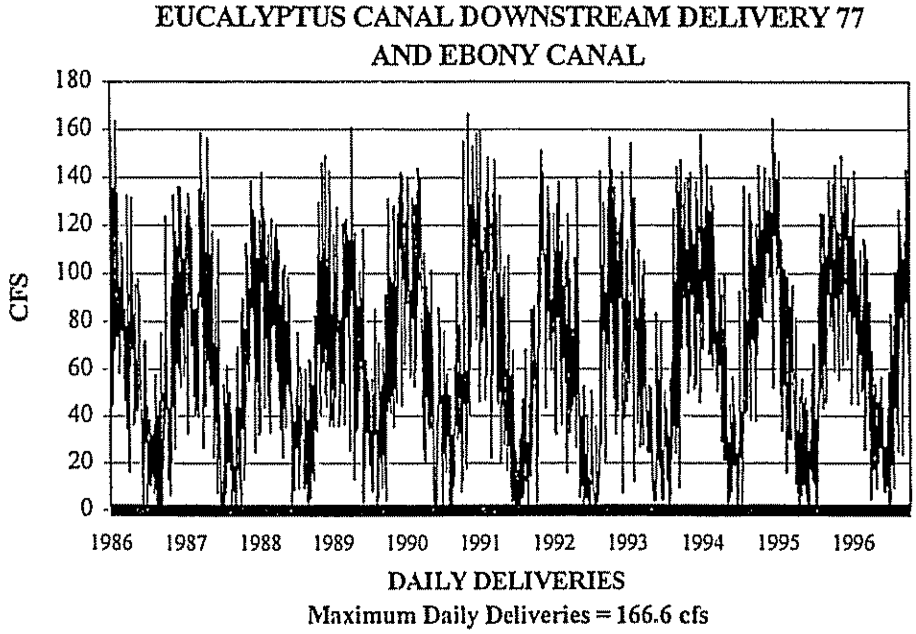


Figure 32: Eucalyptus Canal Downstream Delivery 77 Daily Deliveries

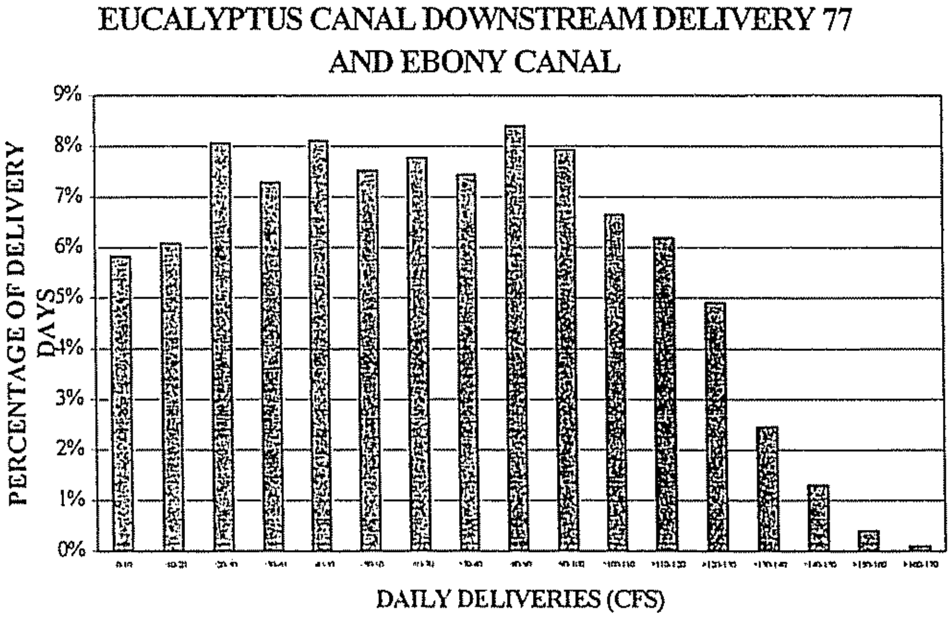


Figure 33: Eucalyptus Canal Downstream Delivery 77 Percentage of Delivery Days

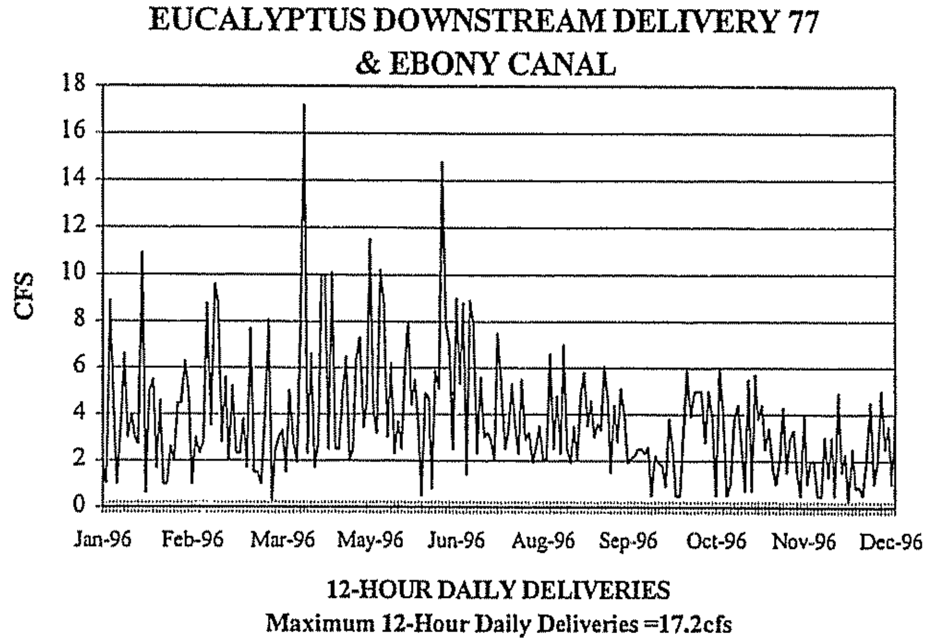


Figure 34: Eucalyptus Canal Downstream Delivery 77, 12-Hour Daily Deliveries

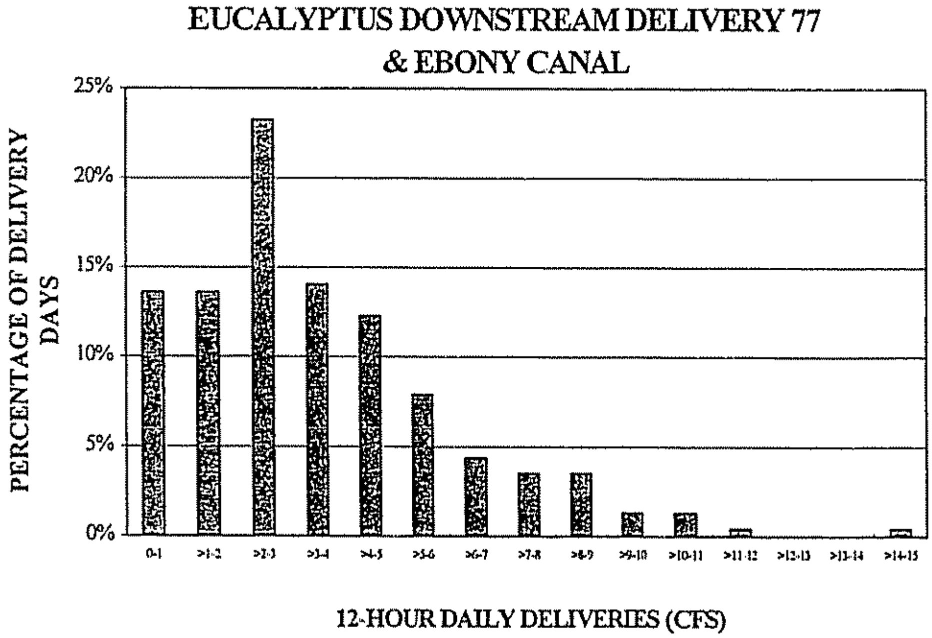


Figure 35: Eucalyptus Canal Downstream Delivery 77, 12-Hour Percentage of Delivery Days

The Eucalyptus Canal - Ebony Canal reservoir would have an estimated annual power cost of \$5,780. The cost associated with a four foot deep 40 acre-foot reservoir include:

- Pond Construction	\$125,450
- Pump and Installation	\$ 20,800
- Structure and Measuring Devices	\$ 37,750
- Total Cost	\$184,000
- Annualized Capital Cost (8%, 35 years)	\$ 15,787
- Annualized Power Cost	\$ 5,780
- Total Annual Cost	\$ 21,567

Appendix D contains data for cost estimates.

3.0 SUMMARY

Evaluation criteria included:

a) cost (gravity in and gravity out flow preferred)

b) number of 12-hour deliveries upstream and downstream of the site,

c) daily deliveries

d) length of lateral

e) unsteadiness (estimated by Division Operations Staff), and

f) lateral discharge volume if known.

Evaluation criteria are applied to each site. Evaluation criteria for gravity in and gravity out flow is located in Appendix A. Appendix B contains evaluation criteria for unsteadiness, Appendix C contains spill data, and Appendix D contains cost estimates.

Ranking the sites by cost show:

1. Alder Canal - Alder Lateral 7 reservoir will cost less over time due to gravity in and out of reservoir outflow, construction cost is estimated at \$165,800.

2. Elder Canal - Elm Canal and Eucalyptus Canal - Ebony Canal reservoirs both will have a power cost associated with the pumped outflow, construction cost is estimated at $184,000.

APPENDIX A

MID-LATERAL RESERVOIR ELEVATION DATA

Mid-Lateral Reservoir Elevation Data

Alder Canal - Alder Lateral 7	Cum. Distance (ft)	East / North NS Elev. (ft)	West / South NS Elev. (ft)	HW Elev. (ft)	West Bank Elev. (ft)	East Bank Elev. (ft)	Top of Structure (ft)	Station 1 (ft)	Station 2 (ft)	Station 3 (ft)
Alder Del 41	0	978.8	-	981.4	981.4	981.8	982.3	33817		
Alder Del 46	1,335	977.9	-	979.8	980.8	981.4	980.4	35152		
Alder Del 47	3,939	*971.5*	-	*974.0*	974.8	975.0	975.6	37756		
US Ald 48/82/Lt7 Check	*3,939*	*971.5*	-	*974.0*	974.8	975.0	975.6	37756		
DS Ald 48/82/Lt7 Check	*4,089*	*972.0*	-	*972.1*	973.7	973.4	975.0	37906		
DS Alder 81 Check	*5,522*		968.9	*968.9*	971.9	971.6	973.2	39339		
DS Alder 83 Check	*7,014*	*968.2*	-	*966.4*	970.3	968.6	970.8	40831		
Change in Feet	*3,075*	*3.3*		*7.6*						
DS Alder Lat 7 Hd Chk	0	-	971.9	970.4	974.0	972.6	974.4	37845	13	
Alder 50/51 Check	2642	967.8	-	969.2	971.4	971.1	971.8		2655	
Alder 52/53 Check	3928	963.6	966.2	966.7	967.8	970.0	969.8		3941	

Elder - Elm Canals	Cum. Distance (ft)	East / North NS Elev. (ft)	West / South NS Elev. (ft)	HW Elev. (ft)	West / South Bank Elev. (ft)	East / North Bank Elev. (ft)	Top of Structure (ft)	Station 1 (ft)	Station 2 (ft)	Station 3 (ft)
Elder Del 71	0	967.2	-	971.2	971.9	973.7	971.7	4033		
Elder Del 75	1,725	966.7	-	970.3	971.6	971.6	971.3	5758		
US Elder 77/Elm/Elm Lt1 Chk	*2,954*	*966.2*	-	*970.3*	971.8	971.7	(C.P.) 971.6	6987		
DS Elder 77/Elm/Elm Lt1 Chk	*3,068*	*962.8*	-	*968.7*	971.7	972.1	971.3	7101		1284
DS Elder 82/83 Check	*5,768*	*966.8*	-	*967.1*	968.7	968.9	969.0	9807		3984
Elder Del 85	7,004	963.8	-	964.8	968.2	968.0	967.3			5220
Change in Feet	*2,814*	*0.6*		*3.2*						
DS Elm Canal Hd Check	0	965.9	961.9	968.9	971.5	970.1	971.6	7087	47	1264
Elm Del 7	2,576	965.0	965.1	968.4	970.4	970.7	969.4		2623	
Hwy 80/Elm Del 10	5,169	963.4	962.7	967.7	969.5	969.7	969.2		5216	

Eucalyptus - Ebony Canals	Cum. Distance (ft)	East NS Elev.	West NS Elev.	HW Elev.	West Bank Elev.	East Bank Elev.	Top of Structure	Station 1	Station 2	Station 3 (ft)
US Euc 73 Check	0	-	-	971.1			971.9	27553		
DS Euc 73 Check	0	968.5	-	969.2	970.3	970.9	971.9	27553		
DS Euc 74A Check	1,379	966.9	-	968.3	969.7	969.8	969.9	28932		
US Euc 77/Ebony Check	*2,748*	*965.1*	-	*968.1*	968.6	969.4	culvt 970.4	30301		
DS Euc 77/Ebony Check	*2,995*	*963.6*	-	*965.7*	967.5	967.6	969.1	30548		
Conc Culvert / RR	*4,496*	*962.0*	-	*965.5*	966.0	965.8	968.2	32049		
Euc 77A	*4,958*	*962.1*	-	*965.1*	966.4	966.2	966.4	32511		
Change in Feet	*2,210*	*3.0*		*3.0*						
DS Ebony Canal Hd	0	963.9	-	968.0	966.6	966.6	969.1	30433	19	
DS Ebony 1 Check	1,281	961.8	-	960.9	963.9	964.3	964.5		1300	
DS Ebony 1A Check	2,630	959.1	-	959.1	961.4	962.5	962.4		2649	

Mid-Lateral Reservoir Elevation Data

Acacia Canal - Acacia Lateral 4

	Cum. Distance (ft)	East NS Elev.	West NS Elev.	HW Elev.	West Bank Elev.	East Bank Elev.	Top of Structure	Station 1	Station 2
Acacia 26 Check	0			985.7	986.6	986.3	986.9	2685	
Acacia 26A	1,222			985.1	986.1	985.9	985.8	3907	
Acacia 27	2,540			985.0	986.0	986.6	985.6	5225	
Aca Lat 4 Head	2,782			984.7	985.3	986.1	985.3	5467	15
Aca 29	5,138			981.4		982.8	982.0		2371
Aca 31 Check	7,897			978.9		980.1	979.2		5130

Acacia Canal - Acacia Lateral 6

	Cum. Distance (ft)	East NS Elev.	West NS Elev.	HW Elev.	West Bank Elev.	East Bank Elev.	Top of Structure	Station 1	Station 2
Acacia 52 Check	0	-	969.4	970.8	972.5	972.4	972.9	4063	
Acacia 53 Check	1,310	-	967.9	970.3	972.1	971.0	971.5	5373	
Acacia 62 Check	2,614	-	968.0	966.1	970.5	969.8	970.3	6677	
Acacia 65	4,738	963.4	-	967.6	968.9	967.9	968.4	8801	
Aca Lat 6 Head	0	-	967.4	969.5	969.1	968.3	970.3	6617	0
Aca 55/55A Check	1,365	-	965.7	964.6	967.0	966.4	968.4		1365

Hemlock Canal - Hemlock Lateral 2B

	Cum. Distance (ft)	East / South NS Elev.	West / North NS Elev.	HW Elev.	West / South Bank Elev.	East / North Bank Elev.	Top of Structure	Station 1	Station 2
Hemlock 6	0			1035.1	1037.0	1036.0	1036.2	3074	
Hemlock 10	1,333			1035.0	1036.0	1036.5	1035.4	4407	
Hem Lat 2B Head	0			1034.4	1035.7	1036.7	1037.0	0	
Hemlock 52	890			1034.3	1035.3	1036.1	1035.6	890	
Hemlock 55	2,997			1034.1	1034.9	1034.5	1035.0	2997	0
Hemlock 57	3,204			1033.8	1035.5	1035.0	1035.0	4435	207
Hemlock 60 Check	4,580			1033.5	1034.4	1036.0	1034.6	6071	1583
Hemlock 14	0			1032.1	1032.4	1032.5	1033.1	17181	
Hemlock 16	3,791			1031.4	1032.4	1032.6	1031.9	20972	

Hemlock Canal - Hemlock Lateral 4

	Cum. Distance (ft)	East / South NS Elev.	West / North NS Elev.	HW Elev.	West Bank Elev.	East Bank Elev.	Top of Structure	Station 1	Station 2
Hemlock 26 Check	0	1027.5	1029.0	1030.2	1032.8	1031.4	1030.8	6723	
Hemlock 29A	3,731	1027.5	1029.0	1029.9	1031.4	1031.6	1031.7	10454	
Hemlock 29	4,629	1026.9	-	1029.8	1031.3	1031.2	1030.4	11352	
Hemlock 30	6,171	1027.0	-	1029.6	1030.7	1030.6	1030.5	12894	
Hemlock 32/33 Check	7,568	1025.4	1025.9	1025.8	1027.1	1027.0	1028.6	14291	
Hemlock 34/35 Check	8,931	1023.5	1023.2	1024.4	1025.5	1024.9	1026.6	15654	

Mid-Lateral Reservoir Elevation Data

Hemlock Canal - Hemlock Lateral 4 Continued	Cum. Distance (ft)	East / South NS Elev.	West / North NS Elev.	HW Elev.	West Bank Elev.	East Bank Elev.	Top of Structure	Station 1	Station 2
Hem Lat 4 Head	0	1029.0	-	1029.6	1031.1	1030.0	1030.5	12959	9
Hemlock 45 Check	198	1028.7	-	1028.7	1031.1	1030.0	1030.6		207
Hemlock 46 Check	1,574	1027.5	-	1027.1	1029.0	1029.4	1029.8		1583
Hemlock 48 Check	2,698	1024.4	-	1024.8	1027.2	1026.8	1027.6		2707

East Highline Lateral 1 - Mesa Lateral 3 Spill	Cum. Distance (ft)	East / South NS Elev.	West / North NS Elev.	HW Elev.	West / South Bank Elev.	East / North Bank Elev.	Top of Structure	Station 1	Station 2
EHL1 134 Check	0	1028.3	-	1028.0	1030.4	1030.6	1030.6	2969	
EHL1 135/136 Check	2,696	-	1023.1	1026.0	1027.2	1027.2	1029.2	5665	0
Mesa Lat 3 Spill Inlet	2,992	-	1024.9	1025.9	1026.9	1027.7	1027.2		296
EHL1 136A Check	4,061	-	1022.7	1024.1	1026.5	1026.2	1027.1		1365
EHL1 137 Check	6,677	-	1020.7	1022.8	1024.6	1023.9	1024.5		3981

Woodbine - Wormwood Canals	Cum. Distance (ft)	East / South NS Elev.	West / North NS Elev.	HW Elev.	West Bank Elev.	East Bank Elev.	Top of Structure	Station 1	Station 2
WB 52	0	-	979.9	981.5	983.1	982.5	982.5	19418	
WB 54 Check	473	-	978.8	980.8	982.1	982.5	982.3	19891	
WB 55 Check	1,947	-	978.4	981.0	981.6	981.8	982.0	21365	
WB 56/57 End	2,787	-	976.8	981.0	982.0	981.7	981.9	22678	
DS WW 40/County Rd	0	977.1	-	979.7	981.2	981.5	979.7		6285
WW 47 Check	1,292	976.8	-	979.6	980.8	982.4	979.6		7577
WW 49	2,637	977.7	-	978.0	979.3	979.7	978.0		8922
WW 51	3,921	975.5	-	974.4	979.3	978.6	977.4		10206

APPENDIX B

ZANJERO ESTIMATES FOR MID-LATERAL RESERVOIRS

Zanjero Estimates for Mid-Lateral Reservoirs

Canal Site	Spill Volume	Unsteadiness - Is canal difficult to keep on order?	Unsteadiness - Does Canal Fluctuate?	Other Comments
Acacia Lat 4	Spills into Rose Canal and is removed from list due to Zanjero statement that there is more spill at Lat 6.			
Acacia Lat 6	More spill than at Lat. 4.	DS Delivery 46/47 lots of 12-hr runs and canal runs short.	Not a lot. Landowner Westscript.	Downstream McCabe Rd the canal flow is restricted.
Alder Alder Lat 7	Spills to Dogwood 6/ Rose Spill	Problem with heading after rebuilt. Jumps around everyday. Lots of service pipes (KOA).	Lots.	
East Highline Lateral 1 Mesa Lat 3 Spill	Yes.	Yes.	Yes.	Added 6/6/97 as requested Locate near EHL Delivery 135/136 and Mesa spill.
Elder Elm	ELD 2075 af/yr, 2.9 cfs mean, ELDLt13 554 af/yr 0.8 cfs mean ELM 1522 af/yr 2.1 cfs mean, ELMLt3 1.2 cfs mean	Too much water at heading in morning from night hydrographer.	Lots of fluctuations at heading. Reservoir would cut travel time from 4 hours to 2 hours. Yes a reservoir would help here.	Better location for midreservoir is at Aten Rd/Del ?
Eucalyptus Ebony	EUC 678 af/yr 0.9 cfs mean, EUC10 342 af/yr 0.5 cfs mean EBO 0.3 cfs mean	No. Lots of vegetable sprinklers In summer, lots of work. Delivery 110 is old split.	Sometimes at night.	EUC at Aten Rd / Lat 10 is better location and where shortage occurs.
Hemlock Lat 2B	Removed from list due to Zanjero stating that Lat 4 is more of a problem to keep on order. Hemlock Canal has capacity problem at the heading near Hwy 98/DS delivery 5			
Hemlock Lat 4	Not a lot.	Can't get enough water at the end. Constriction problem near head at Hwy 98 / downstream delivery 5		Better site than Lat 2B.
Woodbine Wormwood	WW953 af/yr 1.3 cfs	No. Downstream 40/46/55 is where most of the 12-hr runs occur.	WW yes at heading, AAC.	Locate at WB Delivery 55 gate.

APPENDIX C

MID-LATERAL RESERVOIR SPILL DATA

YEAR: 1996

Imperial Irrigation District
Elder Canal Spill
19ELD___129_S
Mean Daily Flow in Cubic Feet per Second

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
01	2.0	1.1	2.5	5.2	6.7	1.6	3.0	4.8	7.1	1.7	4.4	0.9
02	1.6	2.1	3.4	4.8	1.4	3.0	2.1	3.8	7.5	1.8	1.3	2.4
03	1.6	1.0	5.6	1.8	1.4	0.9	2.7	4.9	2.2	2.3	1.1	2.7
04	1.4	4.2	4.4	1.6	2.2	0.3	3.2	2.2	5.2	3.1	0.8	4.1
05	1.1	10.5	1.2	2.1	5.9	0.9	8.5	3.0	2.7	2.6	0.8	3.3
06	0.8	2.1	2.3	1.8	3.9	2.1	1.3	2.7	4.0	6.5	2.7	4.1
07	2.0	0.3	1.4	0.7	0.6	0.8	2.3	3.6	3.6	4.7	2.9	3.5
08	5.6	1.6	1.7	0.5	3.5	1.5	3.2	3.1	4.2	4.6	2.9	1.4
09	3.5	0.3	1.8	0.5	8.4	1.4	1.3	1.3	3.1	1.7	2.6	1.3
10	2.8	1.4	0.7	3.8	1.4	3.2	2.6	2.7	1.6	2.1	3.8	0.3
11	0.8	1.8	1.7	7.5	4.1	2.8	2.2	1.0	3.5	2.2	6.8	0.1
12	2.6	1.4	1.1	2.1	1.1	2.4	2.0	5.7	0.9	4.3	4.4	0.1
13	4.4	1.6	9.5	1.8	2.1	5.4	1.7	2.2	0.6	2.8	0.7	0.0
14	6.4	2.5	6.5	1.5	5.3	3.0	3.0	4.2	3.5	1.3	1.0	0.6
15	2.0	1.8	7.1	0.5	4.0	1.1	2.4	3.6	2.4	1.3	1.4	2.9
16	0.5	0.9	5.3	0.4	2.1	0.7	2.0	4.8	1.9	2.9	2.4	1.7
17	3.5	1.3	3.5	0.0	1.7	0.8	0.8	3.4	3.6	3.9	3.8	1.8
18	5.6	1.8	3.4	1.9	3.1	5.0	1.6	5.2	5.4	1.6	5.1	2.2e
19	3.2	2.4	1.7	5.0	4.3	3.3	4.5	2.0	5.5	2.7	1.2	2.1e
20	0.5	4.3	3.3	1.6e	4.6	7.5	3.4	3.8	4.5	2.5	2.4	4.5e
21	4.1	3.2	2.6	1.6e	2.0	3.2	1.8	0.7	3.8	5.3	2.5	2.8e
22	4.4	0.7	1.4	1.6e	4.5	4.6	3.3	1.1	2.9	4.5	1.9	2.2e
23	4.9	2.3	0.7	2.7	2.8	3.9	1.4	0.4	0.4	5.4	1.5	1.6e
24	3.2	5.4	2.2	1.3	1.6	4.3	4.7	3.4	1.9	4.3	3.1	1.8e
25	5.1	2.7	0.4	1.6	2.3	1.6	2.3	3.5	2.4	3.3	4.2	3.2e
26	4.2	0.8	0.6	3.8	3.6	0.4	3.9	4.1	1.4	3.1	1.6	1.[illegible]
27	1.8	2.5	2.2	9.3	1.9	0.4	8.6	2.4	1.3	2.5	4.7	1.0[illegible]
28	4.2	1.8	2.2	8.4	2.0	8.3	5.4	2.3	3.8	2.1	5.3	0.[illegible]
29	2.6	1.3	3.1	2.2	8.3	5.6	6.0	3.1	2.4	3.1	1.2	1.[illegible]
30	1.7		3.7	0.3	8.8	5.5	2.8	4.8	3.8	2.3	0.9	1.[illegible]
31	1.5		5.8		2.1		3.1	4.7		2.4		1.[illegible]
Total	89.6	65.1	93.0	77.9	107.7	85.5	97.1	98.5	97.1	94.9	79.4	[illegible]
Mean	2.9	2.2	3.0	2.6	3.5	2.9	3.1	3.2	3.2	3.1	2.6	2.[illegible]
Min	0.5	0.3	0.4	0.0	0.6	0.3	0.8	0.4	0.4	1.3	0.7	0.[illegible]
Max	6.4	10.5	9.5	9.3	8.8	8.3	8.6	5.7	7.5	6.5	6.8	4.[illegible]
AC-FT	177.7	129.1	184.5	154.5	213.6	169.6	192.6	195.4	192.6	188.2	157.5	12[illegible]

e - 100% of daily volume estimated
* - 50% or more of daily volume estimated

Mean Flow = 2.9 cfs
Total Volume = 2,075.3 ac-ft

Notes: Day begins at midnight (0000 hrs).
Estimated flow for a missing record gap is computed as the average flow of the records preceding and following the gap equal in number to the missing records in the gap.

Date Printed: 08/01/97

Prepared by: WIS[illegible]

YEAR: 1996

Imperial Irrigation District
Elm Canal Spill
19ELM___054_S
Mean Daily Flow in Cubic Feet per Second

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
01	0.9	0.5	1.8	1.6	1.1	1.3	0.7	3.0	0.6	4.3	2.3	0.5
02	1.2	0.9	1.0	2.1	1.5	2.9	2.3	2.6	1.3	1.0	3.0	1.5
03	1.1	2.2	0.8	3.0	1.8	2.6	2.3	2.6	1.5	2.4	2.9	3.7
04	1.1	2.6 *	1.0	2.3	0.9 *	2.9	1.3	3.0	0.9	1.1	4.5	0.8
05	1.0	2.2e	2.2	2.0 *	1.3e	0.9	0.0	3.4	0.5	0.8	5.7	0.9
06	0.9	2.2e	2.5	2.2e	1.7	0.7	2.9	2.8	0.4	1.1	1.3	1.8
07	0.7	2.2e	2.0	2.5 *	2.0	2.7	4.1	3.0	0.6	1.1	0.8	2.1
08	1.8	2.2e	2.9	1.6	1.9	2.5	3.6	4.6	2.6	0.7	2.1	1.6
09	1.0	2.2e	1.2	1.5	1.3	1.7	3.0	3.3	2.0	1.0	2.8	1.0
10	4.4	2.2e	1.4	3.6	2.7	1.7	2.2	2.3	0.7	2.6	1.3	0.1
11	4.0	1.9 *	2.2	3.8	2.8	2.1	1.4	2.2	1.2	3.5	2.5 *	1.2
12	3.8	0.9	4.0	1.5	2.8	2.6	3.5	3.2	1.6	4.1	2.7e	5.3
13	2.1	0.4	2.8	1.2	1.6	4.2	3.2	1.4	3.2	3.6	2.7e	4.5
14	1.8	4.9	1.2	1.1	0.4	2.0	5.1	0.9	2.3	1.2	2.7e	2.4
15	5.2	3.1	2.1	2.4	1.3	1.4	3.1	0.9	0.9	0.9	2.5 *	1.9
16	3.5	3.4	3.3	2.4 *	1.8	1.1	2.5	0.6	0.9	1.4	3.8	2.4
17	2.3	3.7	2.3	2.2e	1.2	3.1	2.7	2.9	0.3	1.0	1.2	1.9
18	1.5	3.8	2.0	2.2e	1.8	2.3	2.1	1.6	0.7	0.8	1.9	1.7 *
19	3.1	2.7	2.0	2.2e	4.2	1.8	4.3	1.5 *	1.4	1.3	1.4	1.5e
20	4.1	2.0	1.2	2.2e	4.4	3.0	2.5	1.8e	1.7	2.8	1.0	1.7e
21	3.9	0.8	0.9	2.2e	1.7	3.7	3.0	1.8e	1.5	2.5	0.5	2.3e
22	3.5	0.8	0.2	2.2e	4.0	4.5	2.5	1.8e	1.9	2.2	1.8	1.0e
23	3.3	3.2	2.3	1.5 *	3.5	3.5	5.3	1.8e	1.6	1.2	1.5	0.8e
24	2.3	2.3	1.2	2.4	2.9	1.9	4.5	2.4	1.5	1.4	1.8	2.1e
25	3.2	1.9	3.9	3.2	2.3	0.9	3.0	2.3	0.8	1.7	1.4	1.9e
26	2.0	1.8	3.1	2.1	0.9	1.2	1.8	0.1	1.1	1.4 *	1.2	1.2e
27	1.5	4.1	4.9	1.3	2.0	2.8	1.5	2.4	2.7	1.6e	2.1	1.1e
28	2.4	1.8	2.5	0.9	3.8	2.8	3.6	1.9	2.9	1.1 *	1.8	1.0e
29	1.8	2.0	2.2	1.0	2.7	1.7	2.8 *	1.4	2.4	0.3	0.9	1.4e
30	0.9		2.5	1.0	1.8	3.7	2.8e	1.4	3.3	0.0	2.0	1.3e
31	1.5		3.5		2.3		2.4 *	1.8		0.1		1.0e
Total	71.8	64.9	67.1	61.4	66.4	70.2	86.0	66.7	45.0	50.2	64.1	53.6
Mean	2.3	2.2	2.2	2.0	2.1	2.3	2.8	2.2	1.5	1.6	2.1	1.7
Min	0.7	0.4	0.2	0.9	0.4	0.7	0.0	0.1	0.3	0.0	0.5	0.1
Max	5.2	4.9	4.9	3.8	4.4	4.5	5.3	4.6	3.3	4.3	5.7	5.3
AC-FT	142.4	128.7	133.1	121.8	131.7	139.2	170.6	132.3	89.3	99.6	127.1	106.3

e - 100% of daily volume estimated
* - 50% or more of daily volume estimated

Mean Flow = 2.1 cfs
Total Volume = 1,522.1 ac-ft

Notes: Day begins at midnight (0000 hrs).
Estimated flow for a missing record gap is computed as the average flow of the records preceding and following the gap equal in number to the missing records in the gap.

YEAR: 1996

Imperial Irrigation District
Eucalyptus Lateral Spill
98EUC___155_S
Mean Daily Flow in Cubic Feet per Second

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
01	0.0	1.4	0.4	1.6	0.5	2.2	0.0	0.0	0.2	1.3	6.1	1.9
02	0.0	0.3	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.9	6.8	0.2
03	3.0	1.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.2	6.7	0.0
04	1.1	2.7	0.9	0.3	0.9	0.0	0.0	0.0	0.0	0.8	6.0	0.0
05	0.0	1.1	0.0	1.4	2.2	0.0	0.0	1.1	0.2	0.3	6.3	2.4
06	0.0	0.2	0.0	0.9	0.1	0.0	0.2	1.0	1.2	0.0	7.4	0.8
07	0.5	2.3	0.0	0.5	2.3	0.0	0.2	0.5	2.8	0.0	6.5	0.1
08	1.9	0.0	0.0	0.0	2.2	1.9	0.5	0.0	2.0	0.0	3.4	4.0
09	1.7	0.4	0.3	0.0	0.4	1.9	0.8	0.0	1.8	0.0	5.0	5.1
10	1.3	2.0	1.1	0.0	0.4	0.3	1.4	0.2	0.2	0.0	2.5	3.1
11	1.5	0.0	0.4	1.0	0.3	0.0	0.0	0.1	1.0	0.0	3.3	1.5
12	0.9	0.3	0.8	0.4	1.7	0.0	0.2	0.1	0.9	0.1	5.1	1.2
13	1.4	0.5	0.0	0.7	0.8	0.3	0.0	0.1	1.7	0.2	1.6	1.5
14	0.1	0.0	0.2	0.0	0.3	0.0	1.1	0.2	2.8	0.3	0.4	2.1
15	0.3	0.2	0.2	0.0	0.5	0.0	1.1	0.8	1.7	0.9	1.4	2.6
16	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.6	3.0	4.5	1.3
17	2.5	0.0	0.0	0.0	0.5	0.8	0.2	0.0	3.5	2.9	2.6	0.9
18	1.1	0.0	0.0	0.0	0.7	0.0	0.1	0.0	1.8	0.2	2.4	0.2
19	0.6	0.8	1.2	0.0	0.0	1.6	0.3	0.0	0.1	0.0	2.0	1.2
20	0.9	0.2	1.8	0.4	0.0	1.5	0.0	0.0	0.9	0.0	2.2	0.4
21	0.2	0.2	1.7	2.8	0.0	0.0	0.0	0.0	1.1	0.1	1.8	0.2
22	2.8	1.5	3.4	2.4	0.3	0.0	0.0	0.0	0.2	0.4	1.7	1.3
23	3.2	1.6	0.4	0.0	0.0	0.1	0.0	1.1	0.1	0.8	0.0	0.9
24	1.6	0.6	0.0	0.0	0.0	1.8	0.0	1.7	0.0	4.3	0.4	0.0
25	1.3	1.3	0.1	0.1	1.9	0.0	0.0	0.0	0.0	2.2	1.1	0.0
26	0.4	0.5	0.0	0.2	3.3	0.7	0.6	0.0	0.0	0.5	2.5	0.0
27	0.0	0.0	0.0	0.9	1.5e	0.4	1.4	0.5	0.3	1.4	1.4	0.0
28	0.0	0.0	0.3	0.0	0.5*	0.0	1.2	0.0	0.1	1.7	2.4	1.3
29	0.0	0.0	0.0	0.0	0.3	0.0	3.2	0.0	0.3	4.3	1.9	0.4
30	0.1		0.1	1.0	0.4	0.0	2.5	0.9	0.4	5.7	2.2	0.9
31	1.0		1.7		0.0		0.0	3.2		5.9		0.6
Total	29.4	19.3	17.2	14.7	22.0	13.5	15.2	11.5	25.9	39.4	97.6	36.1
Mean	0.9	0.7	0.6	0.5	0.7	0.5	0.5	0.4	0.9	1.3	3.3	1.2
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	3.2	2.7	3.4	2.8	3.3	2.2	3.2	3.2	3.5	5.9	7.4	5.1
AC-FT	58.3	38.3	34.1	29.2	43.6	26.8	30.1	22.8	51.4	78.1	193.6	71.6

e - 100% of daily volume estimated
* - 50% or more of daily volume estimated

Mean Flow = 0.9 cfs
Total Volume = 678.0 ac-ft

Notes: Day begins at midnight (0000 hrs).
Estimated flow for a missing record gap is computed as the average flow of the records preceding and following the gap equal in number to the missing records in the gap.

Imperial Irrigation District
Ebony Canal Spill
19EBO___014_S
Mean Daily Flow in Cubic Feet per Second

YEAR: 1996

DAY	AUG	SEP	OCT	NOV	DEC
01		0.6	0.2	0.5	0.1 *
02		0.4	0.1	1.1	0.0
03		1.2	0.4	0.1	0.0
04		0.7	0.5	0.1	0.0
05		0.7	0.1	0.2	0.2
06		0.7	0.1	0.2	0.9
07		0.4	0.0	0.3	1.1
08	1.6	0.4	0.2	0.3	0.7
09	0.3	0.5	0.5	0.2	0.2
10	0.0	1.7	0.4	0.1	0.0
11	0.5	1.0	0.3	0.1	0.0
12	0.3	0.6	0.7	0.1	0.0
13	1.1	1.9	0.6	0.1	0.2
14	0.6	0.9	0.7	0.1	0.6
15	0.5	0.5	1.2	0.0	0.8
16	0.2	0.6	0.2	0.1	0.7
17	0.4	0.6	0.2	0.2	0.2
18	0.2	0.3	0.1	0.0	0.1
19	0.9	0.1	0.1	0.0	0.1
20	0.2	0.2	0.0	0.0	0.0
21	0.1	0.1	0.2	0.0	0.0
22	0.1	0.1	0.2	0.0	0.0
23	0.7	0.3	0.1	0.0	0.0
24	0.8	0.2	0.2	0.1	0.2
25	0.6	0.0	0.0	0.0	0.0
26	1.0	1.1	0.0	0.6	0.0
27	0.8	0.1	0.0	0.4	0.0
28	0.4	0.5	0.0	0.2	0.0
29	0.3	0.3	0.0	0.2e	0.0
30	0.1 *	0.0	0.0	0.2e	0.0
31	0.3		0.0		0.0
Total	12.0	16.7	7.3	5.5	6.1
Mean	0.5	0.6	0.2	0.2	0.2
Min	0.0	0.0	0.0	0.0	0.0
Max	1.6	1.9	1.2	1.1	1.1
AC-FT	23.8	33.1	14.5	10.9	12.1

e - 100% of daily volume estimated
* - 50% or more of daily volume estimated

Mean Flow = 0.3 cfs
Total Volume = 94.4 ac-ft

Notes: Day begins at midnight (0000 hrs).
Estimated flow for a missing record gap is computed as the average flow of the records preceding and following the gap equal in number to the missing records in the gap.

YEAR: 1997

Imperial Irrigation District
Ebony Canal Spill
19EBO___014_S
Mean Daily Flow in Cubic Feet per Second

DAY	JAN	FEB	MAR	APR	MAY	JUN
01	0.0	0.0	0.5	0.1	0.1	0.1
02	0.0	0.0	0.5	0.2	0.0	0.9
03	0.0	0.0	0.2	0.1	0.0	0.5
04	0.0	0.0	0.0	0.0	0.0	0.3
05	0.2	0.5	0.0	0.0	0.3	0.2
06	0.1	0.3	0.0	0.0	0.5	0.7
07	0.0	0.1	0.1	0.0	0.3	0.4
08	0.1	0.3	0.2	0.0	0.3	0.4
09	0.1	0.4	0.1	0.1	0.3	0.4
10	0.1	0.1	0.0	0.0	0.8	0.7
11	0.1	0.0	0.0	0.0	0.3	0.2
12	0.1	0.0	0.1	0.0	0.3	0.2
13	0.3	0.0	0.1	0.1	0.2	2.6
14	0.2	0.0	0.0	0.0	0.6	0.9
15	0.0	0.0	0.0	0.0	0.5	0.6
16	0.1	0.2	0.0	0.0	0.8	0.5
17	0.2	0.0	0.1	0.1	0.3	1.3
18	0.3	0.1	0.1	0.1	0.3	0.4
19	0.1	0.2	0.0	0.0	0.3	0.8
20	0.1	0.2	0.0	0.2	0.3	0.4
21	0.1	0.0	0.0	0.0	0.1	0.2
22	0.3	0.0	0.0	0.0	0.3	0.4
23	0.1	0.2	0.0	0.0	0.4	0.3
24	0.1	0.0	0.0	0.1	0.2	0.6
25	0.1	0.4	0.5	0.1	0.5	1.2
26	0.1 *	0.2	0.0	0.3	0.5	1.2
27	0.1	0.4	0.1	0.4	0.8	1.4
28	0.0	1.0	0.9	0.0	0.6 *	0.4
29	0.0		0.3	0.0	0.7 *	1.4
30	0.3		0.4	0.1	0.5	0.6
31	0.1		0.0		0.2	
Total	3.4	4.6	4.2	2.0	11.3	20.2
Mean	0.1	0.2	0.1	0.1	0.4	0.7
Min	0.0	0.0	0.0	0.0	0.0	0.1
Max	0.3	1.0	0.9	0.4	0.8	2.6
AC-FT	6.7	9.1	8.3	4.0	22.4	40.1

e - 100% of daily volume estimated
* - 50% or more of daily volume estimated

Mean Flow = 0.3 cfs
Total Volume = 90.6 ac-ft

Notes: Day begins at midnight (0000 hrs).
Estimated flow for a missing record gap is computed as the average flow of the records preceding and following the gap equal in number to the missing records in the gap.

YEAR: 1996

Imperial Irrigation District
Wormwood Lateral Spill
98WW____090BS
Mean Daily Flow in Cubic Feet per Second

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
01	1.4	1.3	3.2	0.6	1.1	0.8 *	0.0	6.1	0.0	0.5	2.2e	2
02	1.6	1.3	1.5	1.9	0.8	0.6	0.3	7.4	0.3	0.8	1.2 *	1
03	1.8	2.5	0.6	1.5	1.2	1.4	1.0	3.8	0.4	0.1	2.0	1
04	2.0	2.4	1.3	0.0	0.3	2.2	6.0	0.0	1.7	0.0	0.5	2
05	1.4	3.1	0.3	0.0	4.0	1.8	3.3	0.6	2.5	0.8	0.5	2
06	1.2	1.5	0.5	0.0	3.7	1.4	1.5	5.1	1.7	1.9	0.4	2
07	1.2	2.0	0.0	4.1	1.3	0.2	0.0	1.9	3.2	2.6	2.8	3
08	0.1	1.1	0.0	3.0	0.9	0.4	0.0	1.3	2.6	2.6	2.6	2
09	1.5	0.0	0.0	1.1	1.5	0.7	0.0	3.7	1.7	1.7	2.2	1
10	1.3	0.0	0.0	1.6	2.9	0.8	0.0	5.9	4.3	1.2	0.4	1
11	0.7	0.0	0.0	1.3	2.7	1.8	0.0	1.8	2.4	0.0	0.6	1
12	0.0	0.0	1.4	2.8	1.5	2.2	0.0	1.4	0.3	0.0	0.3 *	1
13	0.0	0.8	1.0	3.9	0.0	1.0	0.5	1.1	1.2	0.2	0.6 *	2
14	0.0	0.3	0.4	2.0	1.9	1.0	0.6	0.5	1.4	0.0	1.3	2
15	0.0	0.0	0.7	0.7	4.1	2.0	0.6	2.1	0.0	1.2	0.9	1
16	0.3	0.0	0.2	2.3	2.9	3.0	2.1	2.6	0.1	4.4	2.7	0
17	1.9	0.0	0.3	3.4	2.0	1.9	0.4	0.0	2.9	2.3	1.4	1
18	0.9	0.0	0.7	0.9	3.3	1.2	3.1	0.1	1.1	2.5	1.2	1
19	2.7	0.1	1.1	0.5	5.6	2.2	2.4	0.3	0.1	0.4	1.2	2
20	1.3	0.1	0.9	0.8	3.7	1.2	1.1	0.1	0.0	2.0	2.0	2
21	2.8	0.0	0.0	0.5	1.1	1.1	0.0	0.1	1.2	2.3	0.0	0
22	3.0	0.0	0.0	0.9	1.7	1.1	0.6	0.6	2.2	0.6	0.0	0
23	0.0	0.0	0.0	0.8	2.2	1.3	1.3	0.3	1.5	1.8	0.0	0
24	0.0	0.0	0.0	1.6	1.1	2.7	1.5	0.0	2.2	3.1	0.1	C
25	0.2	0.0	0.0	1.0	0.4	1.5	1.1	2.4	2.8	1.7	0.1	C
26	0.3	0.0	0.0	1.0	0.1	0.2	0.3	2.7	3.4	3.4	0.2	C
27	0.0	0.1	0.5	1.8	1.0	1.5	1.1	1.2 *	2.6	2.7	1.9	C
28	0.0	1.1	0.8	1.6	1.6	1.8	0.9	1.3e	0.0	1.1	3.6	C
29	0.0	2.5	1.2	0.9	1.1	1.5	0.0	2.1 *	0.2	2.2 *	3.9	C
30	1.9		1.1	0.9	2.5	0.5	0.8	0.8	0.4	2.4e	0.8	C
31	3.3		0.1		1.4 *		2.0	0.0		2.4e		
Total	32.8	20.2	17.8	43.4	59.6	41.0	32.5	57.3	44.4	48.9	37.6	4
Mean	1.1	0.7	0.6	1.4	1.9	1.4	1.0	1.8	1.5	1.6	1.3	
Min	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	
Max	3.3	3.1	3.2	4.1	5.6	3.0	6.0	7.4	4.3	4.4	3.9	
AC-FT	65.1	40.1	35.3	86.1	118.2	81.3	64.5	113.7	88.1	97.0	74.6	9

e - 100% of daily volume estimated
* - 50% or more of daily volume estimated

Mean Flow = 1.3 cfs
Total Volume = 953.9 ac-ft

Notes: Day begins at midnight (0000 hrs).
Estimated flow for a missing record gap is computed as the average flow of the records preceding and following the gap equal in number to the missing records in the gap.

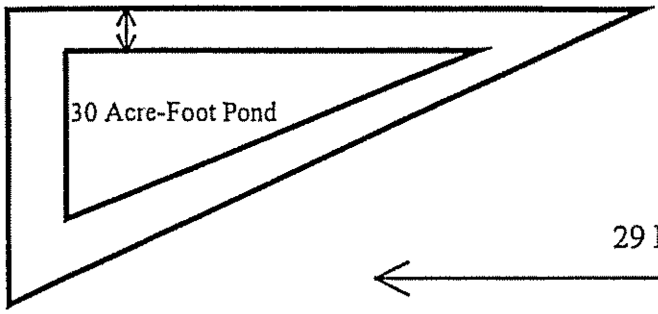
APPENDIX D

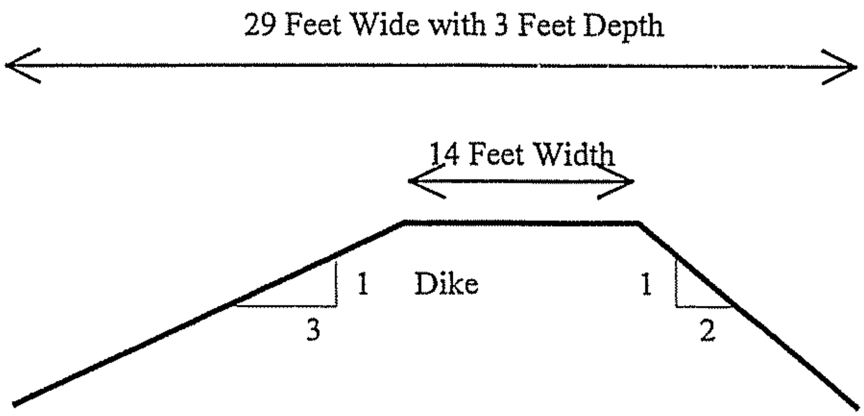
MID-LATERAL RESERVOIR COST ESTIMATES

Alder-Alder Lateral 7 Mid-Lateral Reservoir Layout

Not Drawn to Scale

29 Feet - Total Dike Width





Pond Volume = 30 acre-feet Pond Depth = 3 feet
Pond Volume Estimate = (3' x 0.5 x 1780' x 625') = 1,668,750 cubic feet = 61,806 cubic yards = 1.4 acre-feet
Sand for Trench = 2083' x 1' x 1.5' = 3,125 cubic feet = 116 cubic yards

Berm Volume	**Pond Volume: Triangle Shape, 625' x 1780'x 1886' with 3' Depth**	
49,329 cu ft	1,668,750 cu ft	Gross Pond Volume
152337 cu ft	1,303,002 cu ft	Net Pond Volume = Pond Volume - Berm Volume
164082 cu ft	61,806 cu yd	Gross Pond Volume
365,748 cu ft	1.42 ac-ft	Gross Pond Volume

Alder-Alder Lateral 7 Mid-Lateral Reservoir Cost Estimate

POND - 30 Acre-Foot Volume

4 Excavators remove 3,080 cubic yards of earth per day

6,1806/3,080 = 20 days construction for pond

Note: All costs per hour on labor includes overhead charges.

Quantity	Description	Rate Per Each	Total Cost	Daily Rate	Total Pond
4	Earthmovers Scrapers	$55.00	$220.00	$1,540.00	$30,800.00
1	Dozer	$42.00	$42.00	$294.00	$5,880.00
1	Grader	$41.15	$41.15	$288.05	$5,761.00
1	Truck, Sprinkler	$45.00	$45.00	$225.00	$4,500.00
6	Move Trucks & Operation (50 Miles Round Trip)	$82.82	$496.92	-	$993.84
4	Pickups @ 50 Miles/Day	$5.13	$20.50	$20.50	$410.00
4	Heavy Equipment Operators (Leader)	$40.76	$163.04	$1,467.36	$29,347.20
3	Heavy Equipment Operators #1	$35.21	$105.63	$950.67	$19,013.40
				Total Pond	$96,705.44

PIPE

Quantity	Description	Rate Per Each	Total Cost Per	Daily Rate	Total Pipe
2,083	Green-Tite PVC SDR 35 Sewer Pipe (ft)	$7.40	$15,414.20	-	$15,414.20
2,083	Pipe Installation (per foot includes trencher, labor, and equipment)	$7.00	$14,581.00	-	$14,581.00
127	Sand (cubic yards)	$10.00	$1,270.00	-	$1,270.00
				Total Pipe	$31,265.20

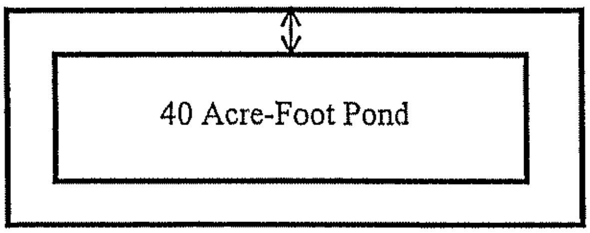
STRUCTURE AND MEASURING DEVICES

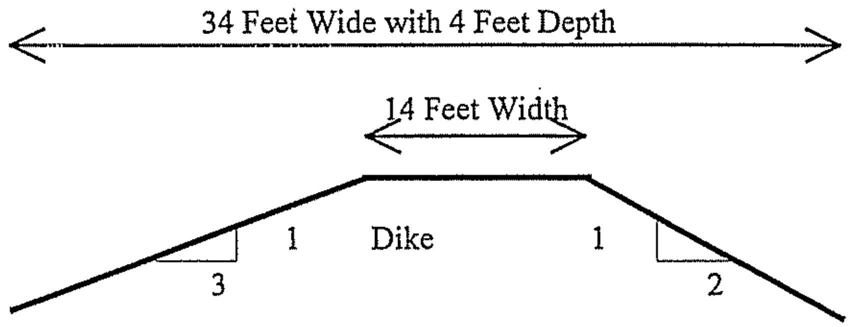
Quantity	Description	Rate Per Each	otal Cost Per	Daily Rate	Total Structures
1	Reservoir Inlet - Automated Drop Leaf Gate (42") with Programmable Logic Controller (PLC)	$17,000.00	$17,000.00	-	$17,000.00
1	Inlet Gate w/PLC Parts, Installation, Calibration, Operation &Maintenance, and Quality Control	$6,000.00	$6,000.00	-	$6,000.00
1	Reservoir Inlet - Check 6'x9'	$4,700.54	$4,700.54	-	$4,700.54
1	Reservoir Outlet - Drop Box w/Extension	$425.00	$425.00	-	$425.00
1	Reservoir Outlet - Close Pipe Meter	$1,500.00	$1,500.00	-	$1,500.00
1	Aluminum Slide Gate for Pipe Outlet	$300.00	$300.00	-	$300.00
1	C&M Worker (Forman)	$40.76	$40.76	$366.84	$733.68
1	C&M Worker (Leader)	$35.21	$35.21	$316.89	$633.78
2	C&M Worker	$31.94	$63.88	$574.92	$1,149.84
1	Crew Trucks @ 50 miles/day	-	$71.50	$71.50	$143.00
1	50 Ton Crane	$70.13	$70.13	$420.78	$841.56
1	Excavator	$44.00	$44.00	$264.00	$528.00
1	Dozer	$42.00	$42.00	$252.00	$504.00
3	Move Trucks & Operation (50 Miles Round Trip)	$82.82	$248.46	-	$496.92
2	Pickups @ 50 Miles/Day	$5.13	$10.25	$10.25	$20.50
2	Heavy Equipment Operators (Leader)	$40.76	$81.52	$733.68	$1,467.36
2	Heavy Equipment Operators #1	$35.21	$70.42	$633.78	$1,267.56
				Total Structure & Measuring	$37,711.74
				Grand Total	**$165,682.38**

Elder-Elm Mid-Lateral Reservoir Layout

Not Drawn to Scale

34 Feet - Total Dike Width





Pond Volume = 40 acre-feet Pond Depth = 4 feet
Pond Volume Estimate = (4' x 1375' x 400') = 2,200,000 cubic feet = 81,481 cubic yards = 1.9 acre-feet

Berm Volume	**Pond Volume: Rectangle Shape, 370' x 1900' with 4' Depth**	
45,152 cu ft	2,200,000 cu ft	Gross Pond Volume
187,000 cu ft	1,735,696 cu ft	Net Pond Volume = Pond Volume - Berm Volume
464,304 cu ft	81,481 cu yd	Gross Pond Volume
	1.87 ac-ft	Gross Pond Volume

Elder-Elm Mid-Lateral Reservoir Cost Estimate

POND - 40 Acre-Foot Volume

4 Excavators remove 3,080 cubic yards of earth per day
81,484/3,080 = 26 days construction for pond
Note: All costs per hour on labor includes overhead charges.

Quantity	Description	Rate Per Each	Total Cost	Daily Rate	Total Pond
4	Earthmovers Scrapers	$55.00	$220.00	$1,540.00	$40,040.00
1	Dozer	$42.00	$42.00	$294.00	$7,644.00
1	Grader	$41.15	$41.15	$288.05	$7,489.30
1	Truck, Sprinkler	$45.00	$45.00	$225.00	$5,850.00
6	Move Trucks & Operation(50 Miles Round Trip)	$82.82	$496.92	-	$993.84
4	Pickups @ 50 Miles/Day	$5.13	$20.50	$20.50	$533.00
4	Heavy Equipment Operators (Leader)	$40.76	$163.04	$1,467.36	$38,151.36
3	Heavy Equipment Operators #1	$35.21	$105.63	$950.67	$24,717.42
				Total Pond	$125,418.92

PUMP

Pump: Two 5 cfs, low head, high volume, mix or axle flow, single stage, oil lube, static head is approximately 13 ft, 15 HP motor, 3 phase
Assumptions: power source and transformer within 50 to 100 feet
Not Included: line transmission costs, check values, gate values, vents, discharge, couplings, etc.

Quantity	Description	Rate Per Each	Total Cost Per	Daily Rate	Total Pump
2	Pump Installation and Start Testing (includes labor & materials)	$8,000.00	$16,000.00	-	$16,000.00
1	Electrical (230 or 460 volt system, 3 phase control panel)	$1,300.00	$1,300.00	-	$1,300.00
1	Electrical Installation (electrical panel, connections, level control, panel support, meter pole, start up testing)	$1,500.00	$1,500.00	-	$1,500.00
1	10% Contingency	$2,000.00	$2,000.00	-	$2,000.00
				Total Pump	$20,800.00

STRUCTURE AND MEASURING DEVICES

Quantity	Description	Rate Per Each	Total Cost Per	Daily Rate	Total Structures
1	Reservoir Inlet - Automated Drop Leaf Gate (42") with Programmable Logic Controller (PLC)	$17,000.00	$17,000.00	-	$17,000.00
1	Inlet Gate w/PLC Parts, Installation, Calibration, Operation & Maintenance, and Quality Control	$6,000.00	$6,000.00	-	$6,000.00
1	Reservoir Inlet - Check 6'x9'	$4,700.54	$4,700.54	-	$4,700.54
1	Reservoir Outlet - Drop Box w/Extension	$425.00	$425.00	-	$425.00
1	Reservoir Outlet - Close Pipe Meter	$1,500.00	$1,500.00	-	$1,500.00
1	Aluminum Slide Gate for Pipe Outlet	$300.00	$300.00	-	$300.00

Elder-Elm Mid-Lateral Reservoir Cost Estimate

STRUCTURE AND MEASURING DEVICES CONTINUED

Quantity	Description	Rate Per Each	Total Cost Per	Daily Rate	Total Structures
1	C&M Worker (Forman)	$40.76	$40.76	$366.84	$733.68
1	C&M Worker (Leader)	$35.21	$35.21	$316.89	$633.78
2	C&M Worker	$31.94	$63.88	$574.92	$1,149.84
1	Crew Trucks @ 50 miles/day	-	$71.50	$71.50	$143.00
1	50 Ton Crane	$70.13	$70.13	$420.78	$841.56
1	Excavator	$44.00	$44.00	$264.00	$528.00
1	Dozer	$42.00	$42.00	$252.00	$504.00
3	Move Trucks & Operation (50 Miles Round Trip)	$82.82	$248.46	-	$496.92
2	Pickups @ 50 Miles/Day	$5.13	$10.25	$10.25	$20.50
2	Heavy Equipment Operators (Leader)	$40.76	$81.52	$733.68	$1,467.36
2	Heavy Equipment Operators #1	$35.21	$70.42	$633.78	$1,267.56
				Total Structure & Measuring	$37,711.74

Grand Total **$183,930.66**

ANNUAL POWER COST

Q = 7.5 cfs (average)

H = 12 feet head (lift + friction)

Efficiency = 0.65

hp = (Q x H) / (8.8 x (Efficiency) = 15.75 x 0.746 kW/hp = 12kW

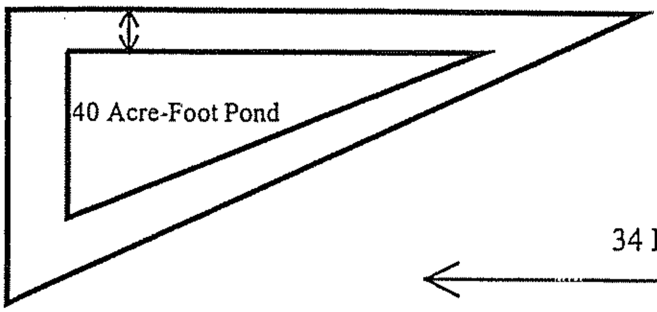
Maximum Annual Power costs = 12 kW x 24 hours/day x 365 days/year = 113,880 kWh @ $.055 = $5,780

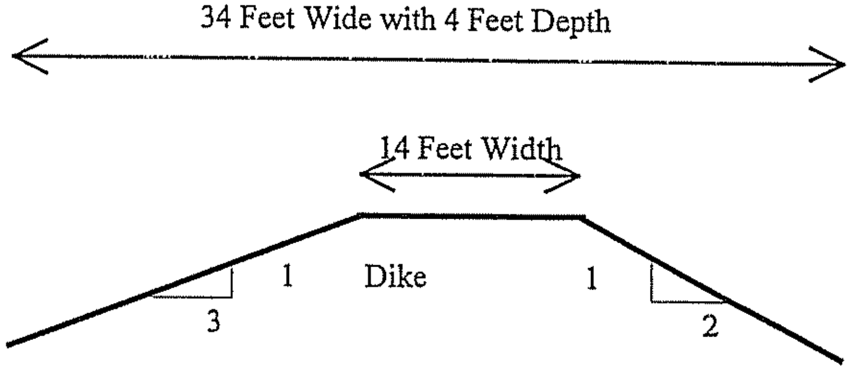
Annual Power Total **5,780.00**

Eucalyptus-Ebony Mid-Lateral Reservoir Layout

Not Drawn to Scale

34 Feet - Total Dike Width





Pond Volume = 40 acre-feet   Pond Depth = 4 feet
Pond Volume Estimate = (4' x 0.5 x 1050' x 1050') = 2,205,000 cubic feet = 81,667 cubic yards = 1.9 acre-feet

Berm Volume	**Pond Volume:**	**Triangle Shape, 1050' x 1050'1485' with 4' Depth**
133,552 cu ft	2,205,000 cu ft	Gross Pond Volume
138176 cu ft	1,731,312 cu ft	Net Pond Volume = Pond Volume - Berm Volume
201960 cu ft	81,667 cu yd	Gross Pond Volume
473,688 cu ft	1.87 ac-ft	Gross Pond Volume

Eucalyptus-Ebony Mid-Lateral Reservoir Cost Estimate

POND - 40 Acre-Foot Volume

4 Excavators remove 3,080 cubic yards of earth per day
81,667/3,080 = 26 days construction for pond
Note: All costs per hour on labor includes overhead charges.

Quantity	Description	Rate Per Each	Total Cost	Daily Rate	Total Pond
4	Earthmovers Scrapers	$55.00	$220.00	$1,540.00	$40,040.00
1	Dozer	$42.00	$42.00	$294.00	$7,644.00
1	Grader	$41.15	$41.15	$288.05	$7,489.30
1	Truck, Sprinkler	$45.00	$45.00	$225.00	$5,850.00
6	Move Trucks & Operation(50 Miles Round Trip)	$82.82	$496.92	-	$993.84
4	Pickups @ 50 Miles/Day	$5.13	$20.50	$20.50	$533.00
4	Heavy Equipment Operators (Leader)	$40.76	$163.04	$1,467.36	$38,151.36
3	Heavy Equipment Operators #1	$35.21	$105.63	$950.67	$24,717.42
				Total Pond	$125,418.92

PUMP

Pump: Two 5 cfs, low head, high volume, mix or axle flow, single stage, oil lube, static head is approximately 13 ft, 15 HP motor, 3 phase
Assumptions: power source and transformer within 50 to 100 feet
Not Included: line transmission costs, check values, gate values, vents, discharge, couplings, etc.

Quantity	Description	Rate Per Each	Total Cost Per	Daily Rate	Total Pump
2	Pump Installation and Start Testing (includes labor & materials)	$8,000.00	$16,000.00	-	$16,000.00
1	Electrical (230 or 460 volt system, 3 phase control panel)	$1,300.00	$1,300.00	-	$1,300.00
1	Electrical Installation (electrical panel, connections, level control, panel support, meter pole, start up testing)	$1,500.00	$1,500.00	-	$1,500.00
1	10% Contingency	$2,000.00	$2,000.00	-	$2,000.00
				Total Pump	$20,800.00

STRUCTURE AND MEASURING DEVICES

Quantity	Description	Rate Per Each	Total Cost Per	Daily Rate	Total Structures
1	Reservoir Inlet - Automated Drop Leaf Gate (42") with Programmable Logic Controller (PLC)	$17,000.00	$17,000.00	-	$17,000.00
1	Inlet Gate w/PLC Parts, Installation, Calibration, Operation & Maintenance, and Quality Control	$6,000.00	$6,000.00	-	$6,000.00
1	Reservoir Inlet - Check 6'x9'	$4,700.54	$4,700.54	-	$4,700.54
1	Reservoir Outlet - Drop Box w/Extension	$425.00	$425.00	-	$425.00
1	Reservoir Outlet - Close Pipe Meter	$1,500.00	$1,500.00	-	$1,500.00
1	Aluminum Slide Gate for Pipe Outlet	$300.00	$300.00	-	$300.00

Eucalyptus-Ebony Mid-Lateral Reservoir Cost Estimate

STRUCTURE AND MEASURING DEVICES CONTINUED

Quantity	Description	Rate Per Each	Total Cost Per	Daily Rate	Total Structures
1	C&M Worker (Forman)	$40.76	$40.76	$366.84	$733.68
1	C&M Worker (Leader)	$35.21	$35.21	$316.89	$633.78
2	C&M Worker	$31.94	$63.88	$574.92	$1,149.84
1	Crew Trucks @ 50 miles/day	-	$71.50	$71.50	$143.00
1	50 Ton Crane	$70.13	$70.13	$420.78	$841.56
1	Excavator	$44.00	$44.00	$264.00	$528.00
1	Dozer	$42.00	$42.00	$252.00	$504.00
3	Move Trucks & Operation (50 Miles Round Trip)	$82.82	$248.46	-	$496.92
2	Pickups @ 50 Miles/Day	$5.13	$10.25	$10.25	$20.50
2	Heavy Equipment Operators (Leader)	$40.76	$81.52	$733.68	$1,467.36
2	Heavy Equipment Operators #1	$35.21	$70.42	$633.78	$1,267.56
			Total Structure & Measuring		$37,711.74

Grand Total **$183,930.66**

ANNUAL POWER COST

Q = 7.5 cfs (average)

H = 12 feet head (lift + friction)

Efficiency = 0.65

hp = (Q x H) / (8.8 x (Efficiency) = 15.75 x 0.746 kW/hp = 12kW

Maximum Annual Power costs = 12 kW x 24 hours/day x 365 days/year = 113,880 kWh @ $.055 = $5,780

Annual Power Total **5,780.00**

APPENDIX E

DELIVERY DATA FOR INITIAL SITES

ACACIA CANAL DELIVERY DATA

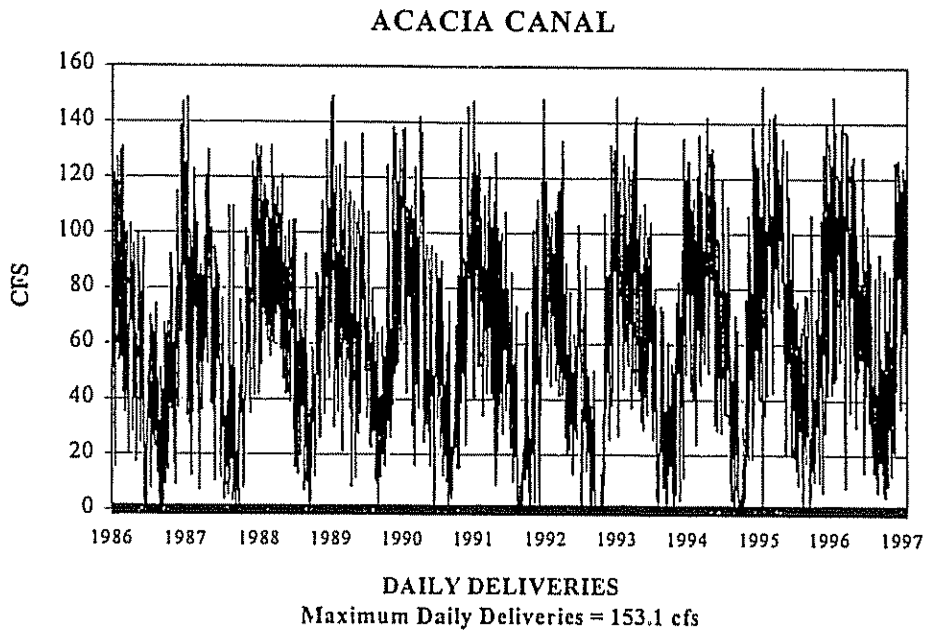


Figure 36: Acacia Canal Heading Daily Deliveries

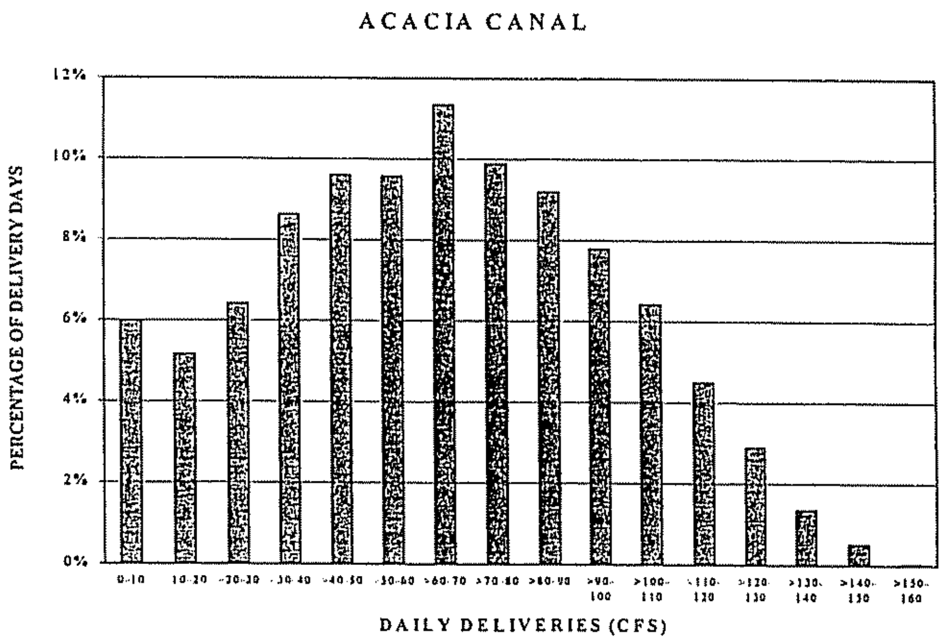


Figure 37: Acacia Canal Heading Percentage of Delivery Days

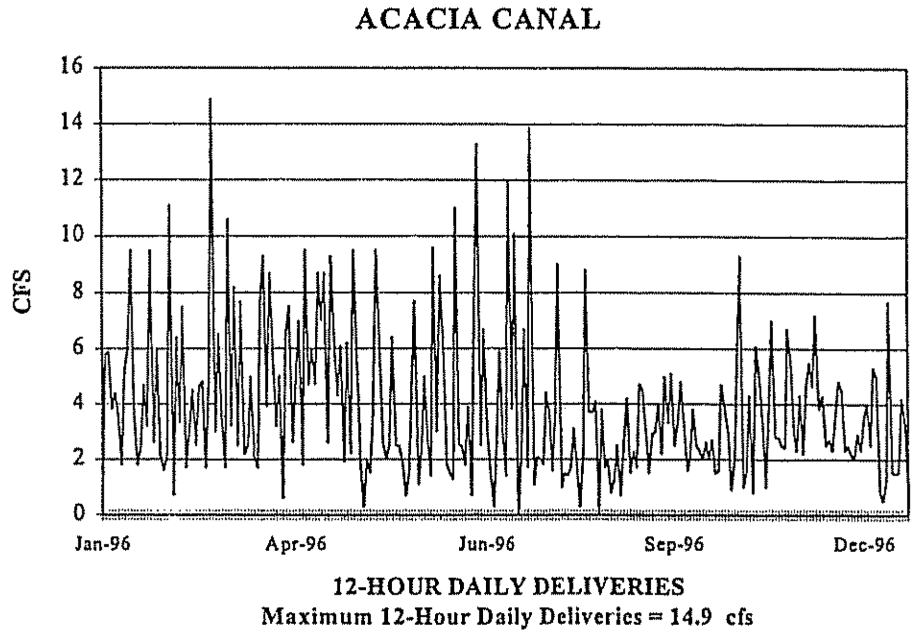


Figure 38: Acacia Canal Heading 12-Hour Daily Deliveries

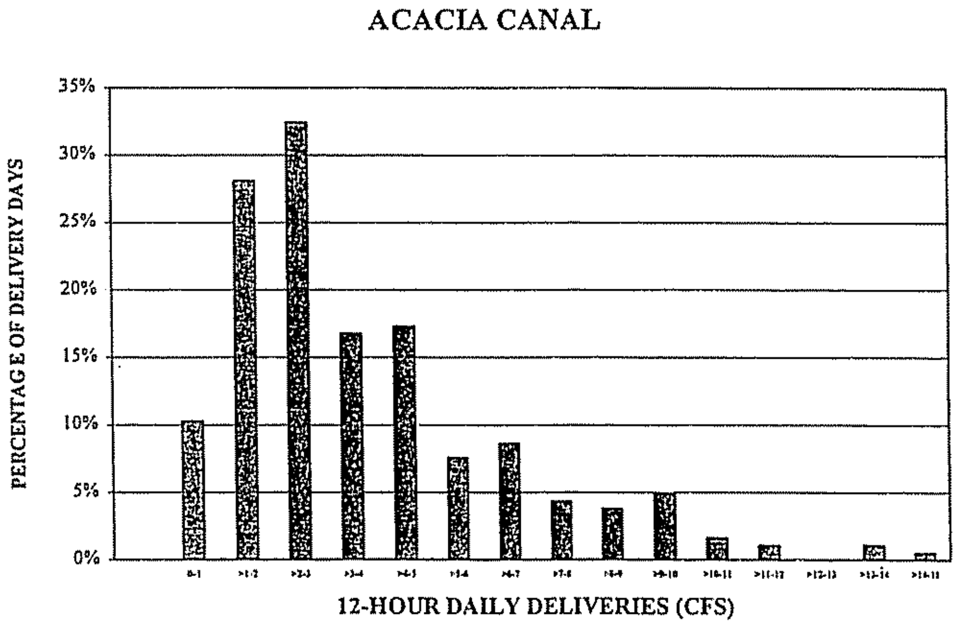


Figure 39: Acacia Canal Heading 12-Hour Percentage of Delivery Days

ACACIA CANAL - ACACIA LATERAL 4 DELIVERY DATA

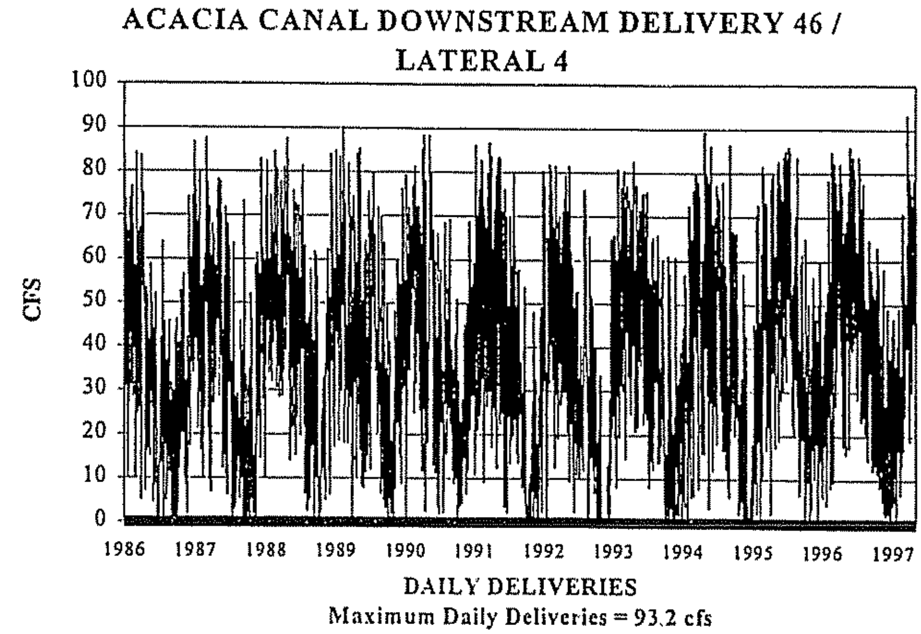


Figure 40: Acacia Canal Downstream Delivery 46 Daily Deliveries

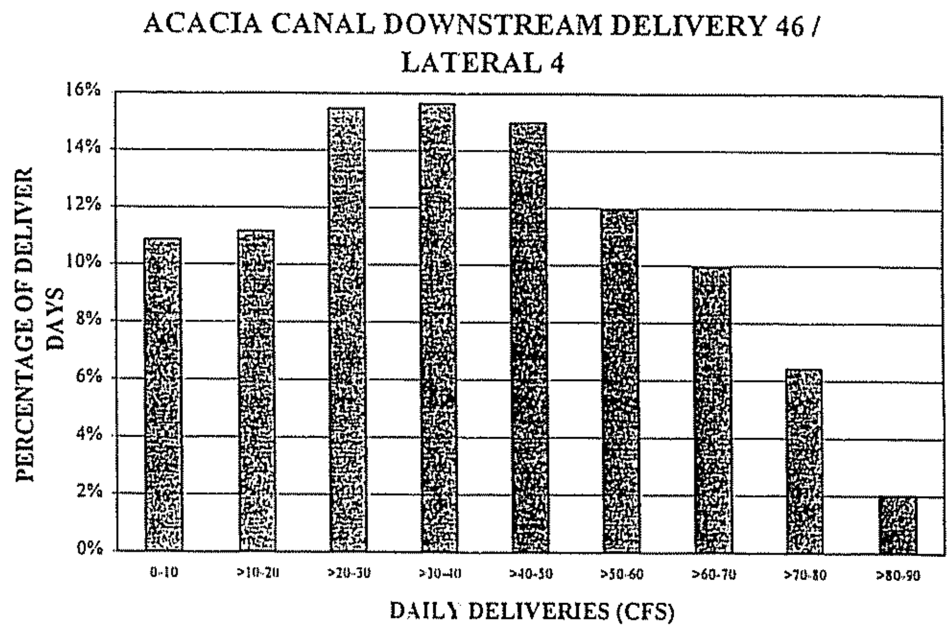


Figure 41: Acacia Canal Downstream Delivery 46 Percentage of Delivery Days

ACACIA CANAL - ACACIA LATERAL 6 DELIVERY DATA

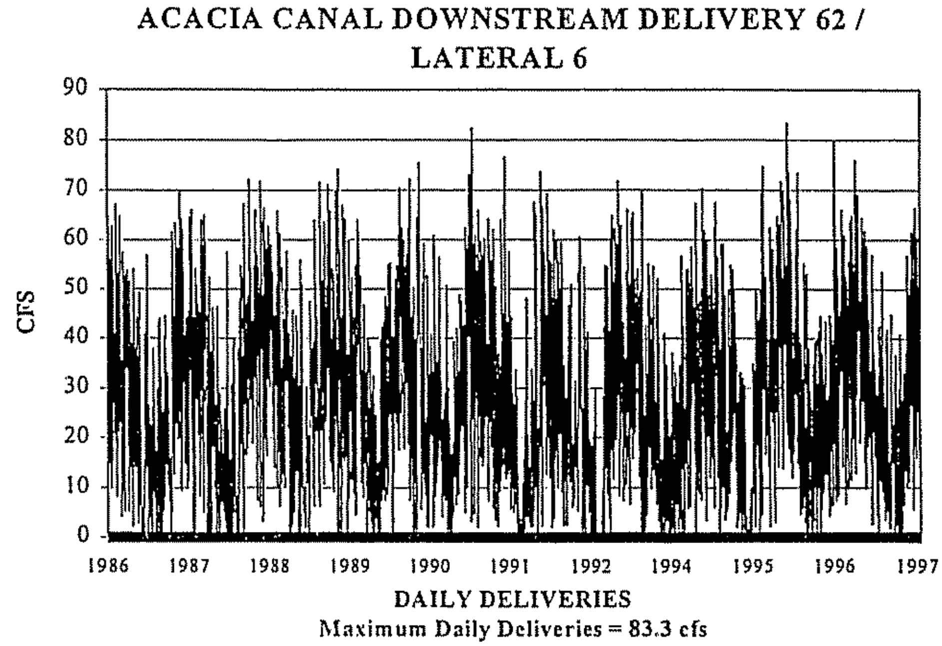


Figure 42 Acacia Canal Downstream Delivery 62 Daily Deliveries

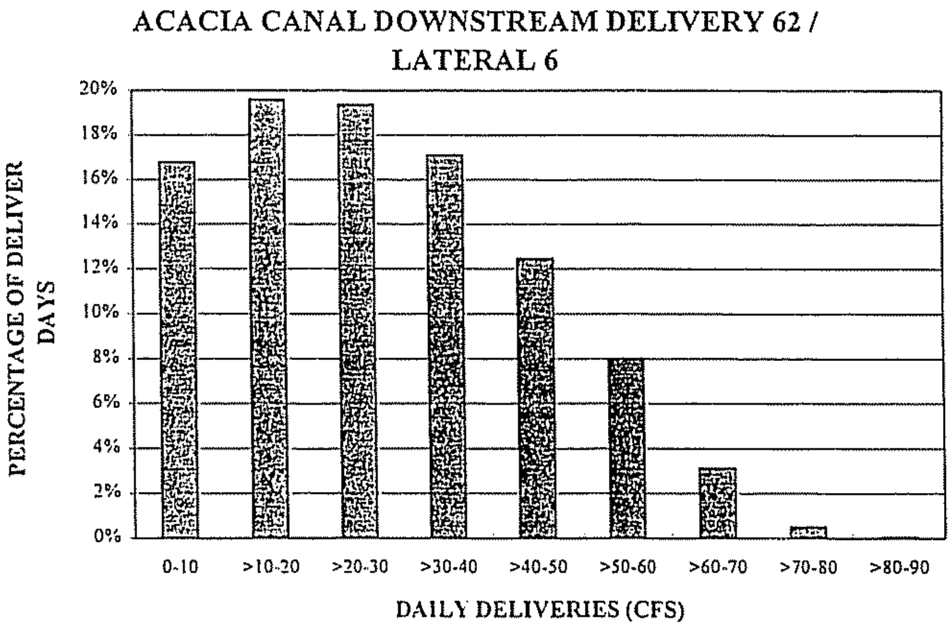
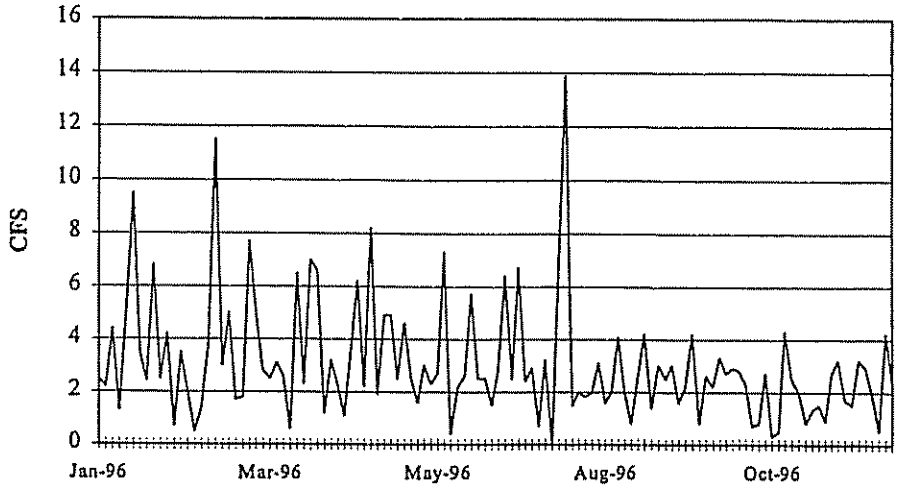


Figure 43 Acacia Canal Downstream Delivery 62 Percentage of Delivery Days

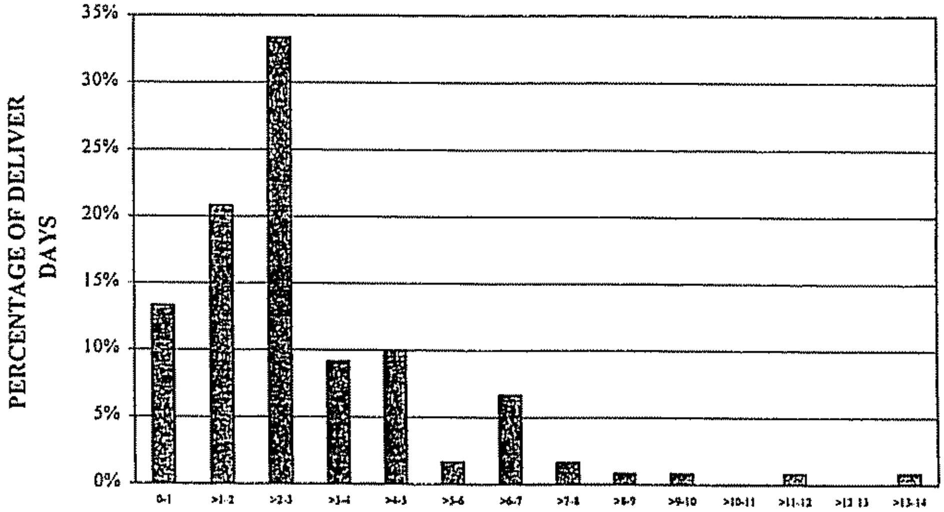
ACACIAL CANAL
DOWNSTREAM DELIVERY 62 / LATERAL 6



12-HOUR DAILY DELIVERIES
Maximum 12-Hour Daily Deliveries = 13.9 cfs

Figure 44 Acacia Canal Downstream Delivery 62, 12-Hour Daily Deliveries

ACACIA CANAL
DOWNSTREAM DELIVERY 62 / LATERAL 6



12-HOUR DAILY DELIVERIES (CFS)

Figure 45 Acacia Canal Downstream Delivery 62, 12-Hour Percentage of Delivery Days

EAST HIGHLINE LATERAL 1 - MESA LATERAL SPILL DELIVERY DATA

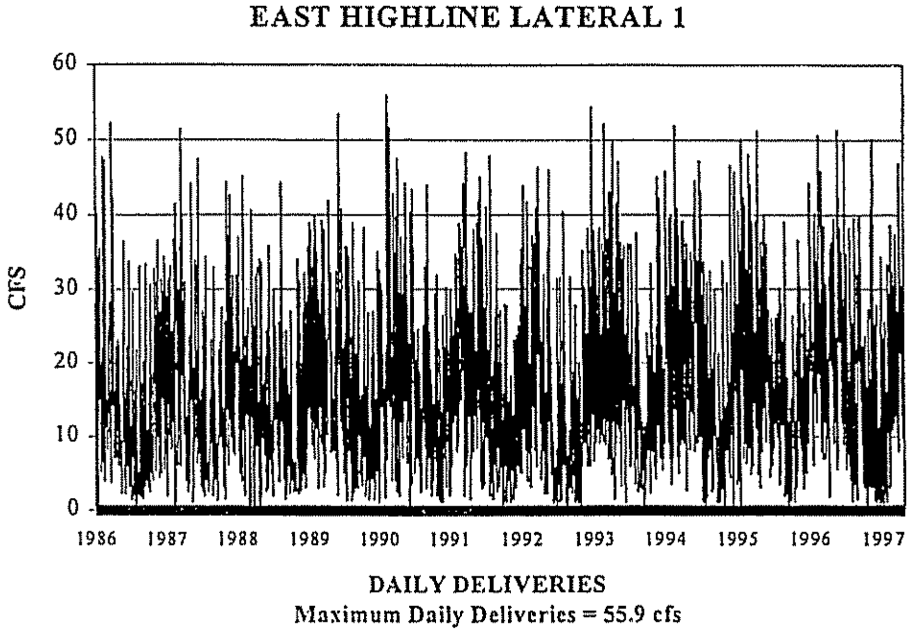


Figure 46 East Highline Lateral 1 Heading Daily Deliveries

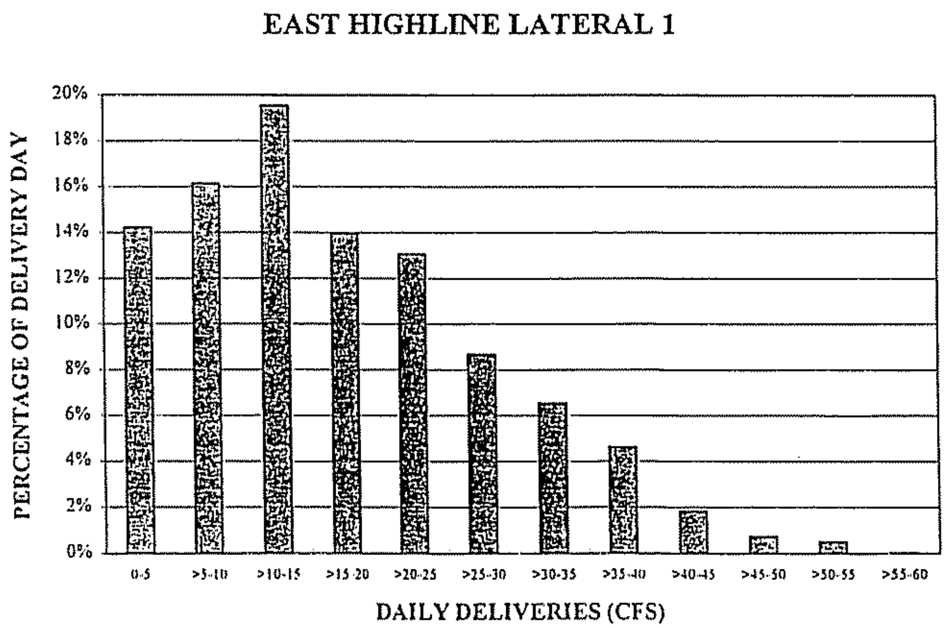


Figure 47 East Highline Lateral 1 Heading Percentage of Delivery Days

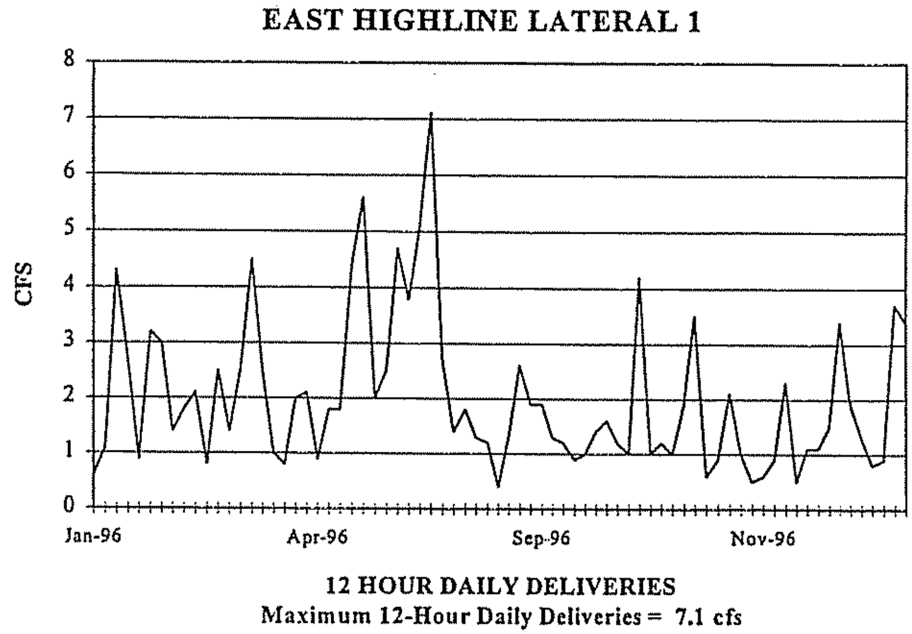


Figure 48 East Highline Lateral 1 Heading 12-Hour Daily Deliveries

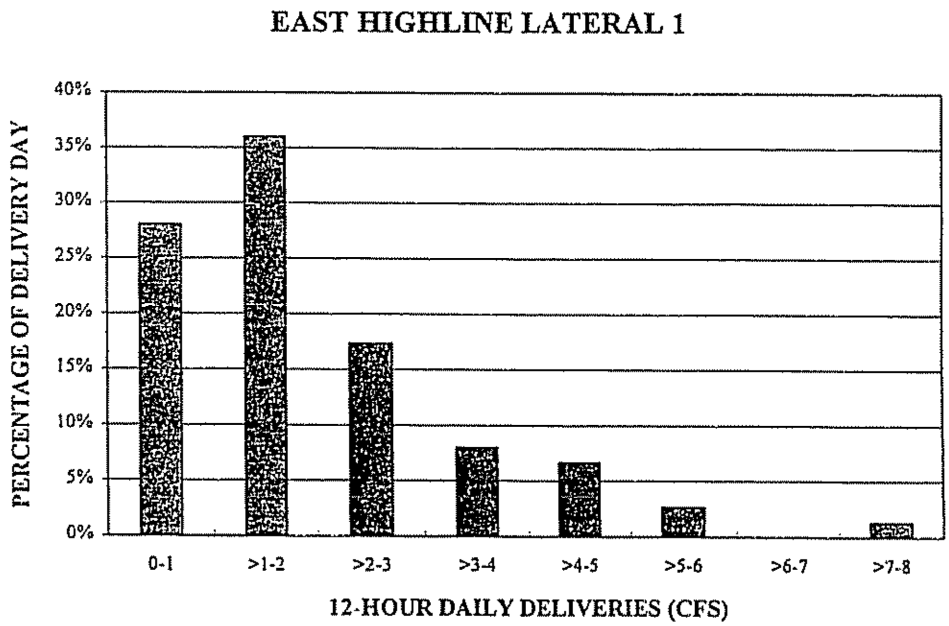


Figure 49 East Highline Lateral 1 Heading 12-Hour Percentage of Delivery Days

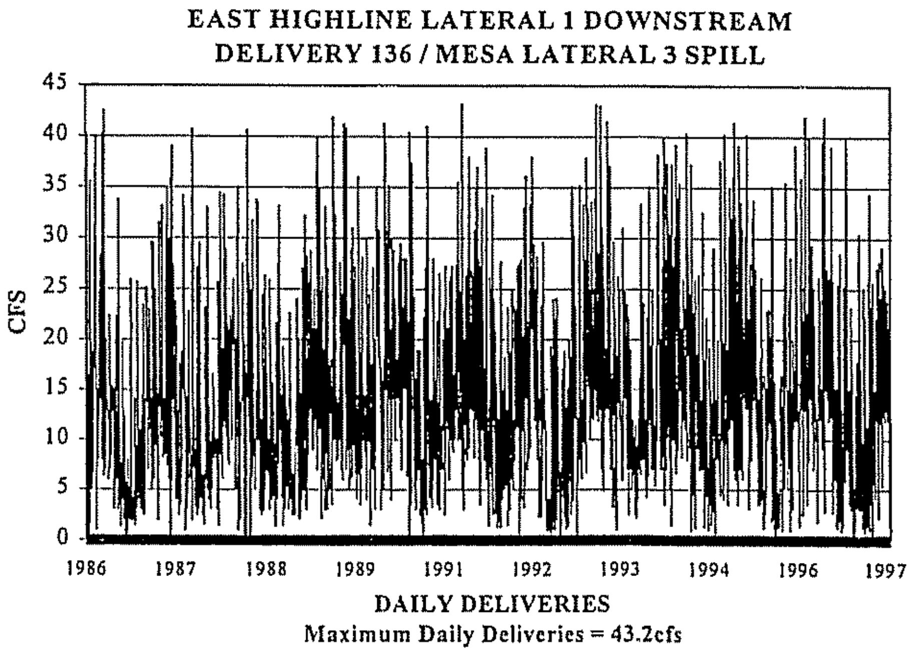


Figure 50 East Highline Lateral 1 Downstream Delivery 136 Daily Deliveries

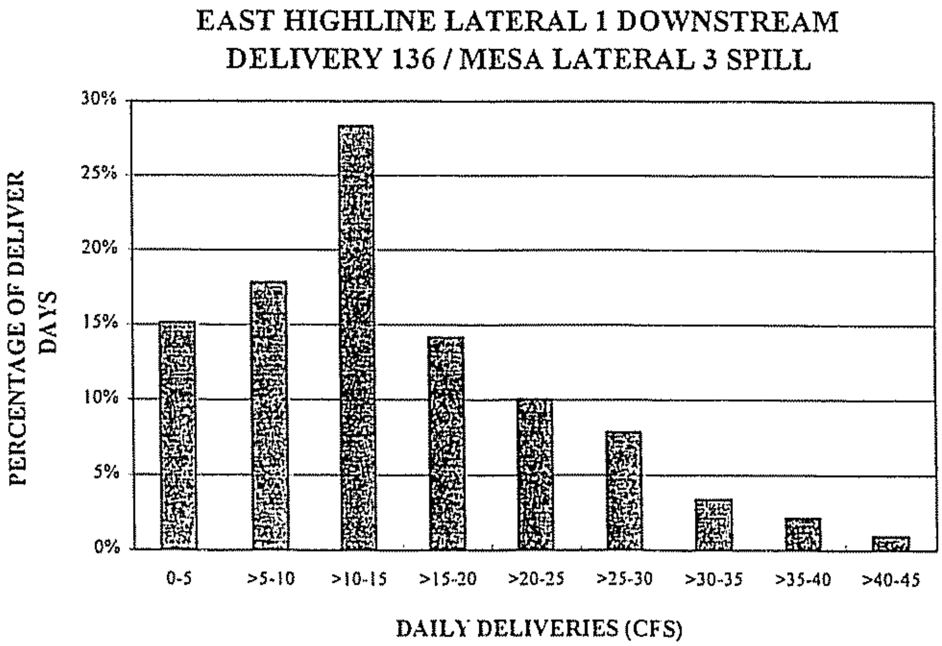


Figure 51 East Highline Lateral 1 Downstream Delivery 136 Percentage of Delivery Days

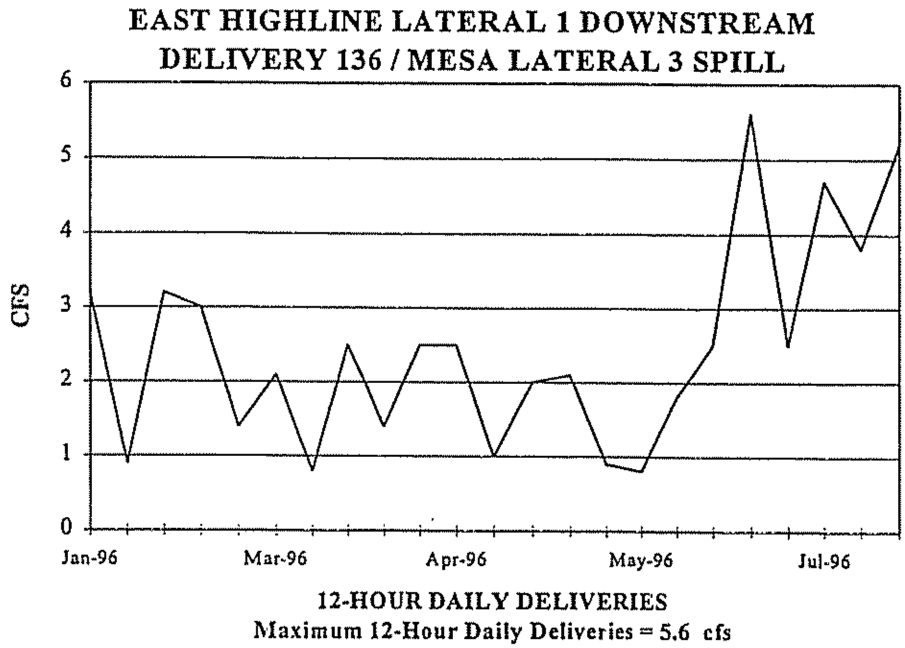


Figure 52 East Highline Lateral 1 Downstream Delivery 136, 12-Hour Daily Deliveries

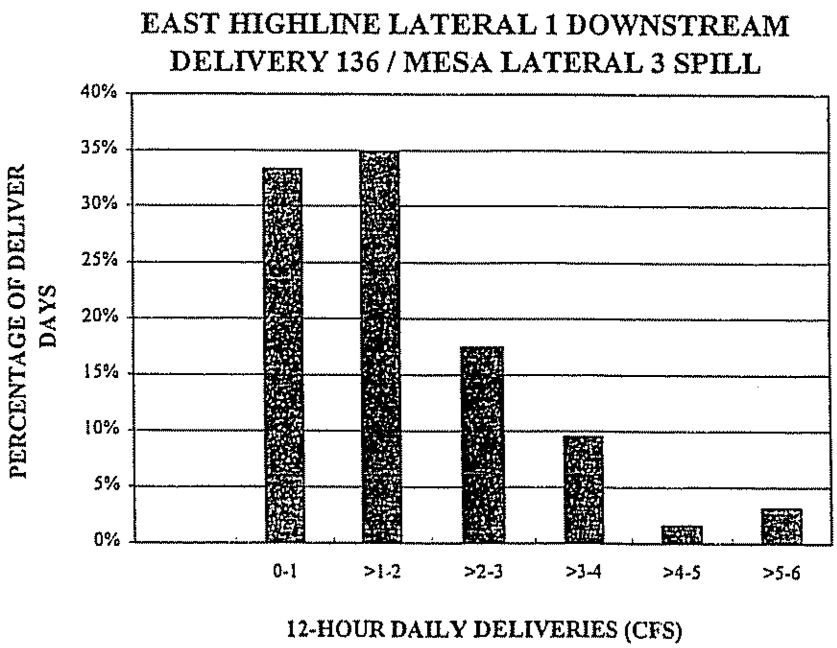


Figure 53 East Highline Lateral 1 Downstream Delivery 136, 12-Hour Percentage of Delivery Days

HEMLOCK CANAL DELIVERY DATA

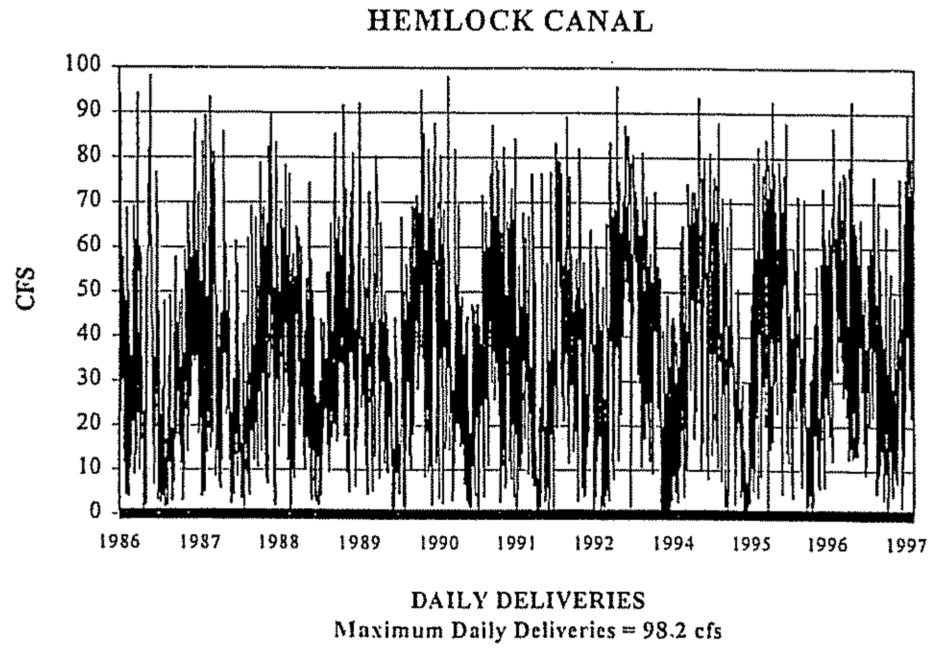


Figure 54: Hemlock Canal Heading Daily Deliveries

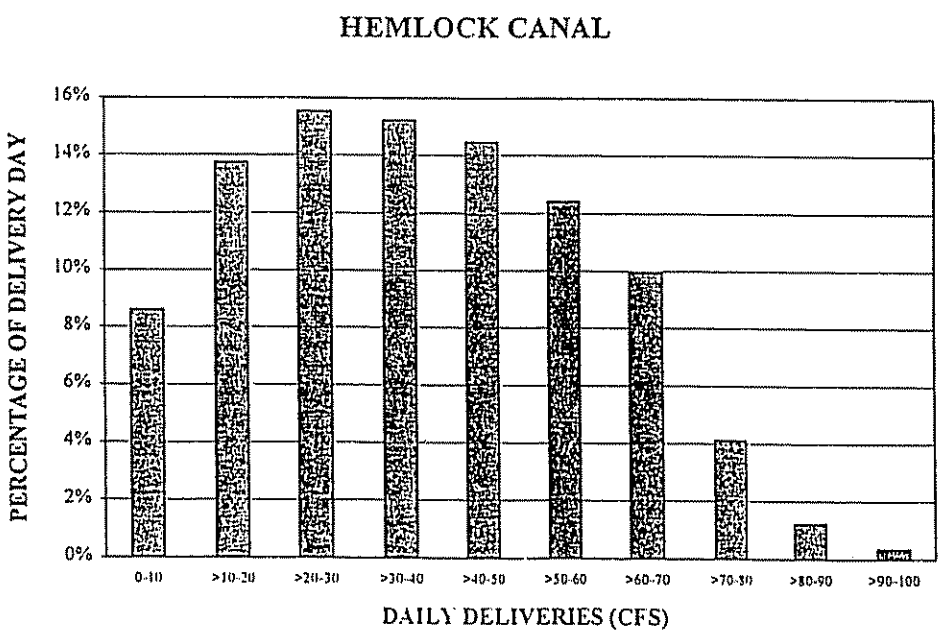


Figure 55: Hemlock Canal Heading Percentage of Delivery Days

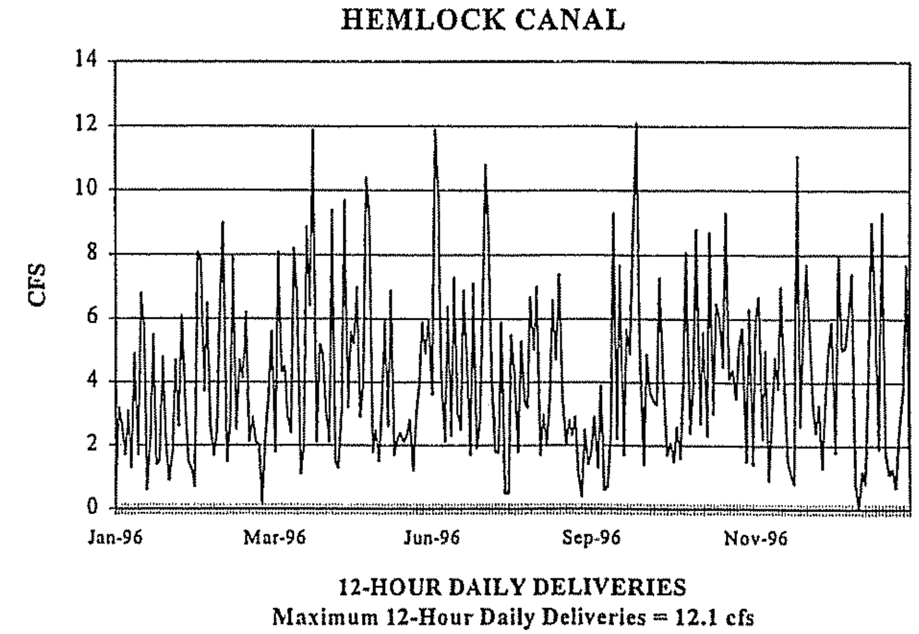


Figure 56: Hemlock Canal Heading 12-Hour Daily Deliveries

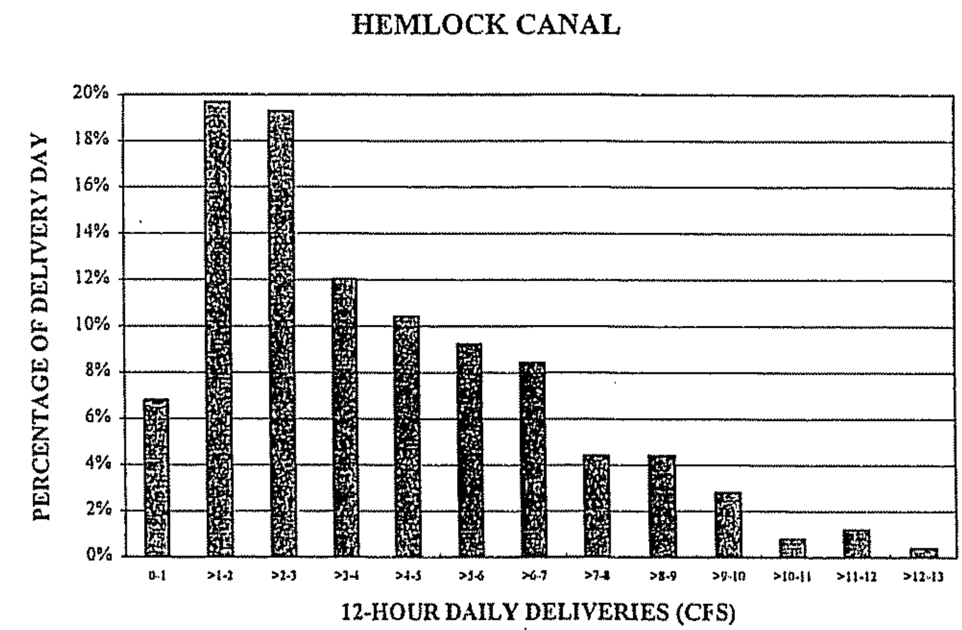


Figure 57: Hemlock Canal Heading 12-Hour Percentage of Delivery Days

HEMLOCK CANAL - HEMLOCK LATERAL 2B DELIVERY DATA

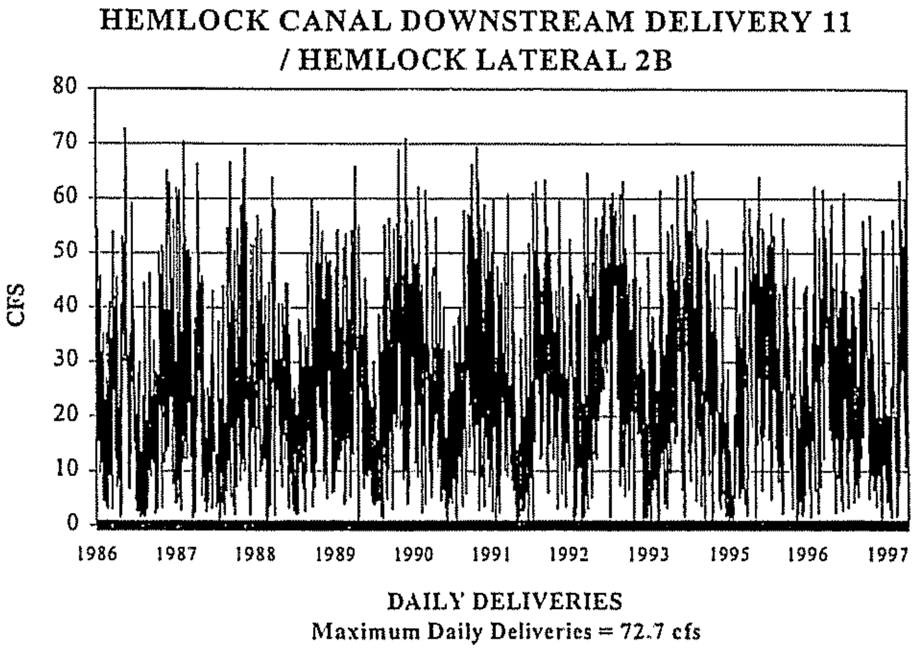


Figure 58: Hemlock Canal Downstream Delivery 11 Daily Deliveries

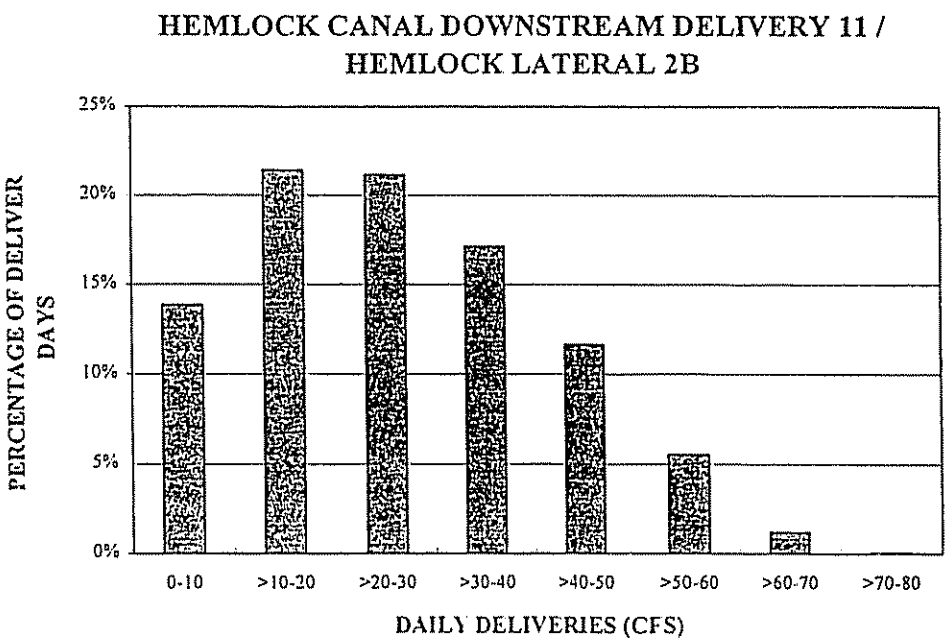


Figure 59: Hemlock Canal Downstream Delivery 11 Percentage of Delivery Days

HEMLOCK CANAL - HEMLOCK LATERAL 4 DELIVERY DATA

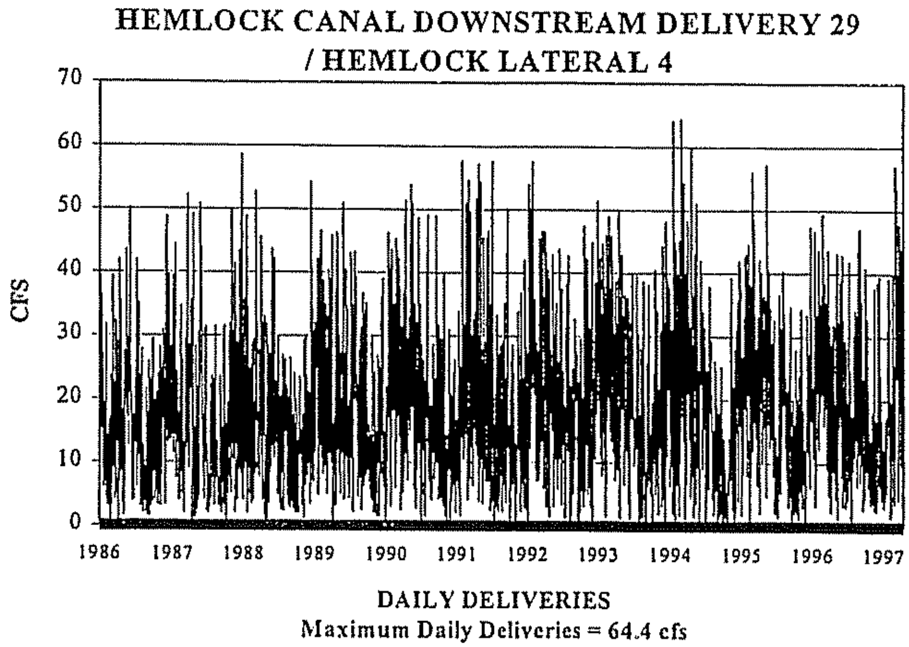


Figure 60: Hemlock Canal Downstream Delivery 29 Daily Deliveries

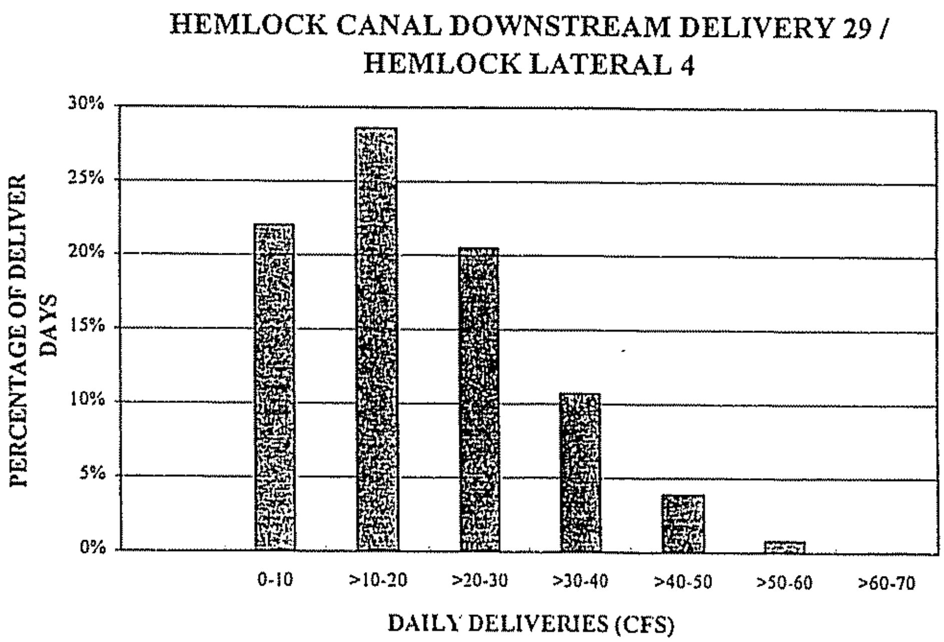


Figure 61: Hemlock Canal Downstream Delivery 29 Percentage of Delivery Days

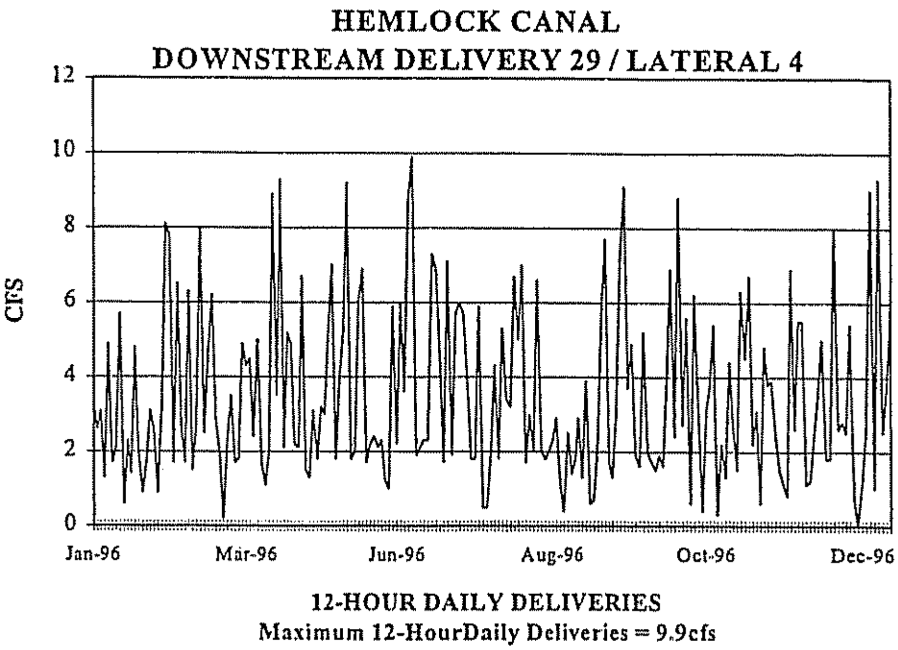


Figure 62: Hemlock Canal Downstream Delivery 29, 12-Hour Daily Deliveries

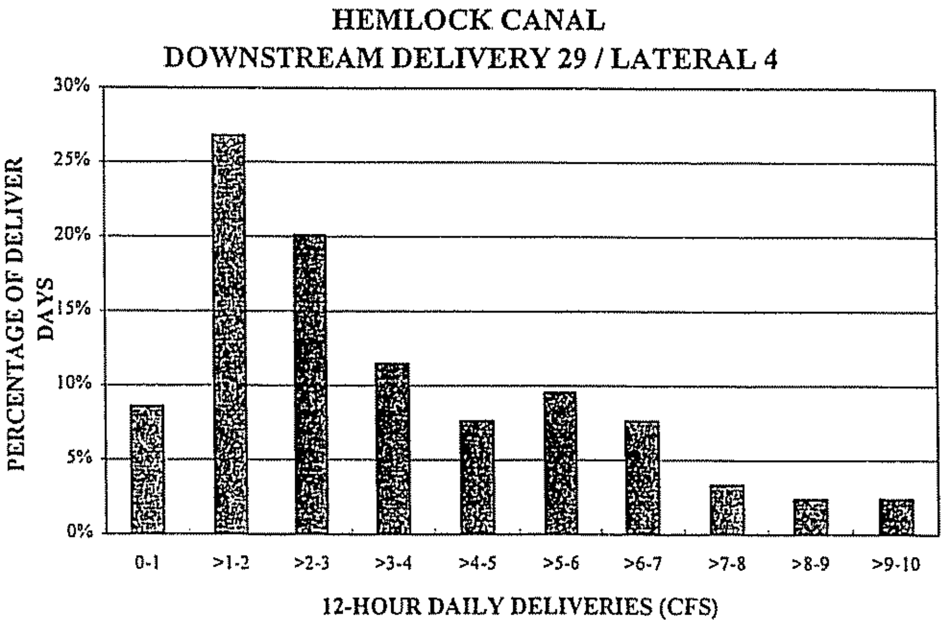


Figure 63: Hemlock Canal Downstream Delivery 29, 12-Hour Percentage of Delivery Days

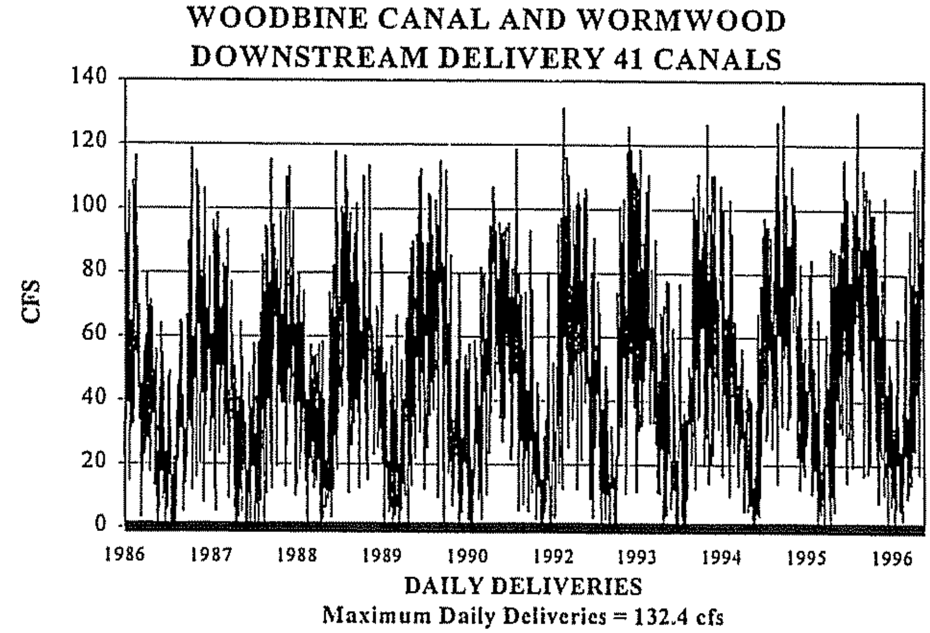


Figure 64: Woodbine Canal And Wormwood Downstream Delivery 41 Daily Deliveries

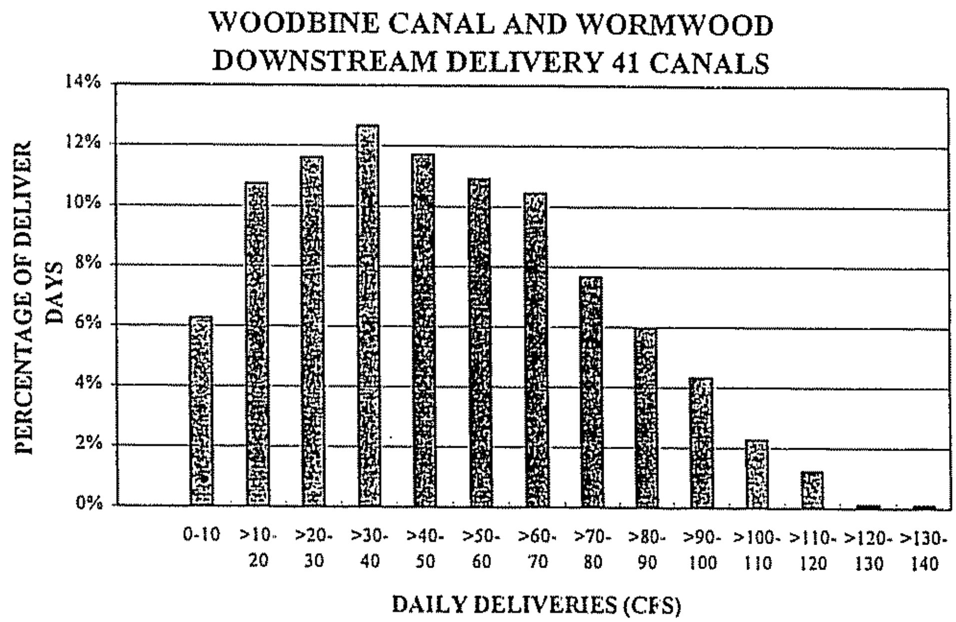


Figure 65: Woodbine Canal And Wormwood Downstream Delivery 41 Percentage of Delivery Days

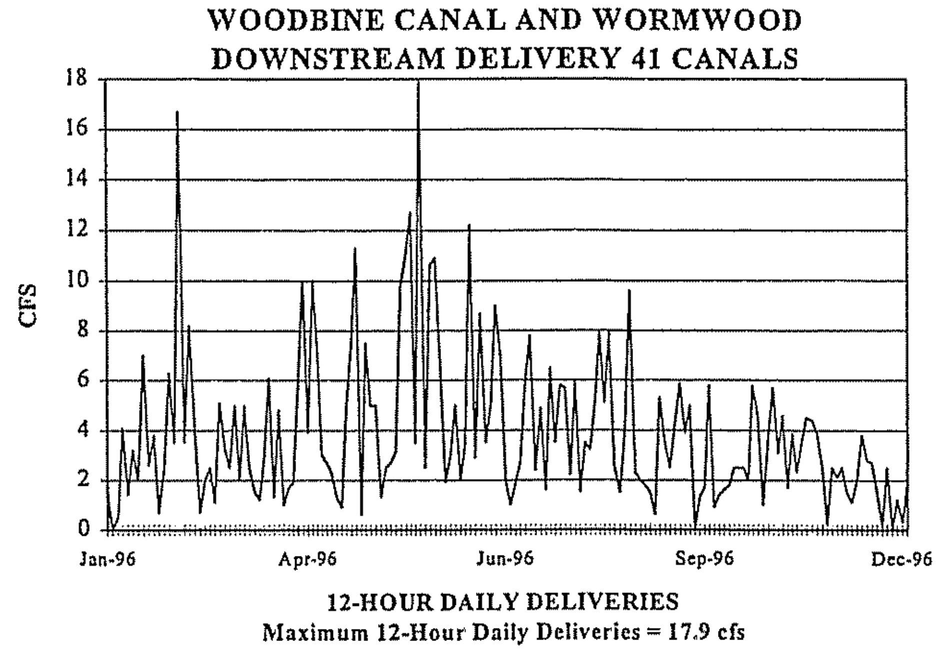


Figure 66: Woodbine Canal And Wormwood Downstream Delivery 41, 12-Hour Daily Deliveries

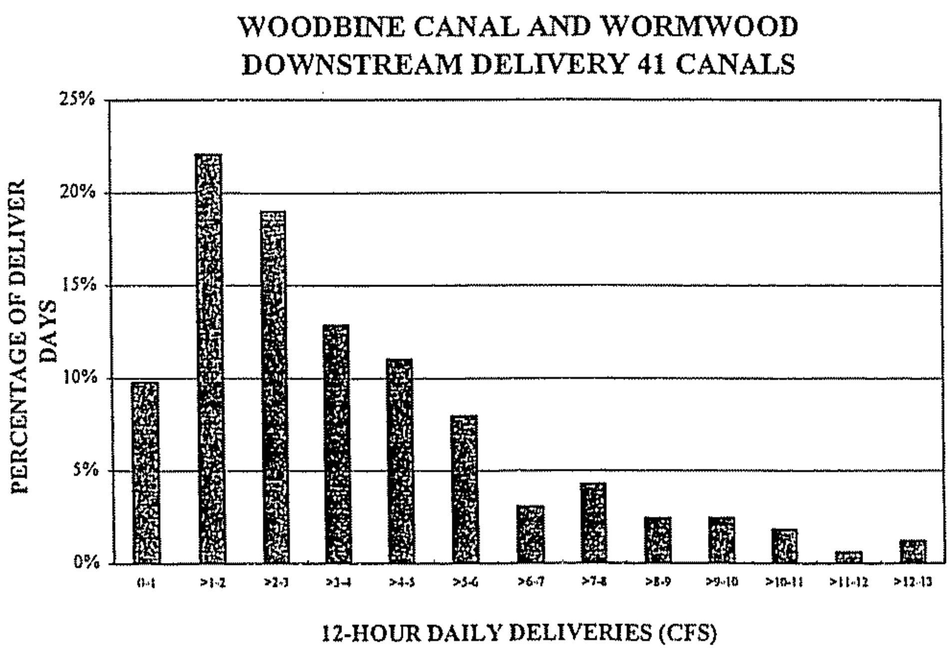


Figure 67: Woodbine Canal And Wormwood Downstream Delivery 41, 12-Hour Percentage of Delivery Days

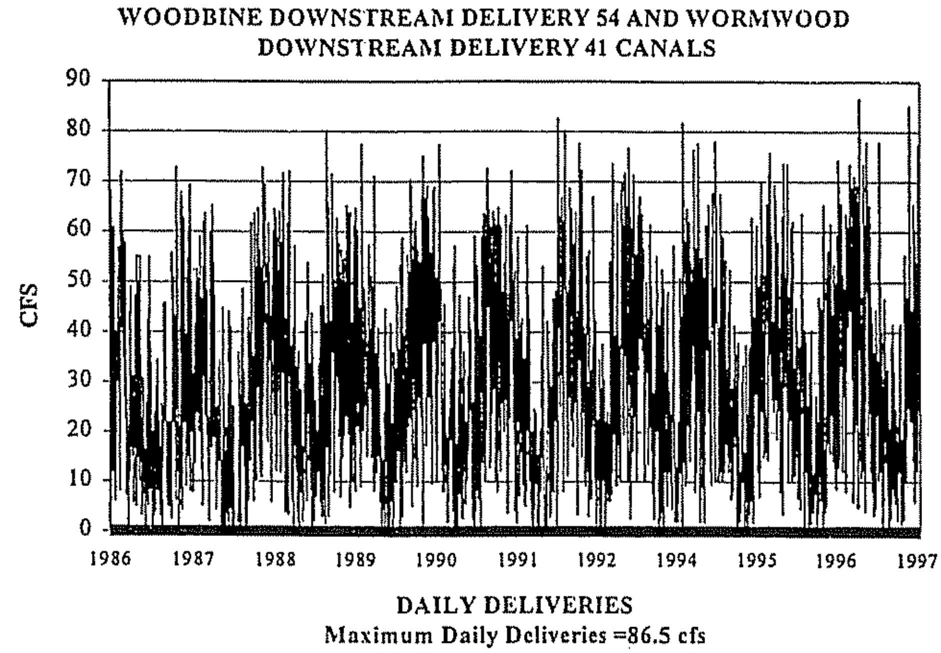


Figure 68: Woodbine Downstream Delivery 54 And Wormwood Downstream Delivery 41 Daily Deliveries

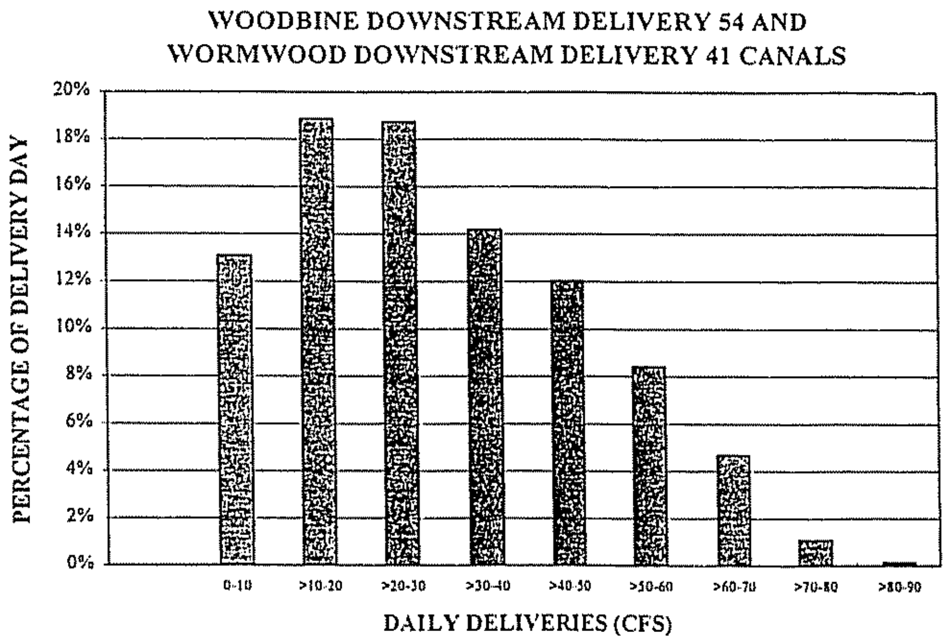


Figure 69: Woodbine Downstream Delivery 54 And Wormwood Downstream Delivery 41 Percentage of Delivery Days

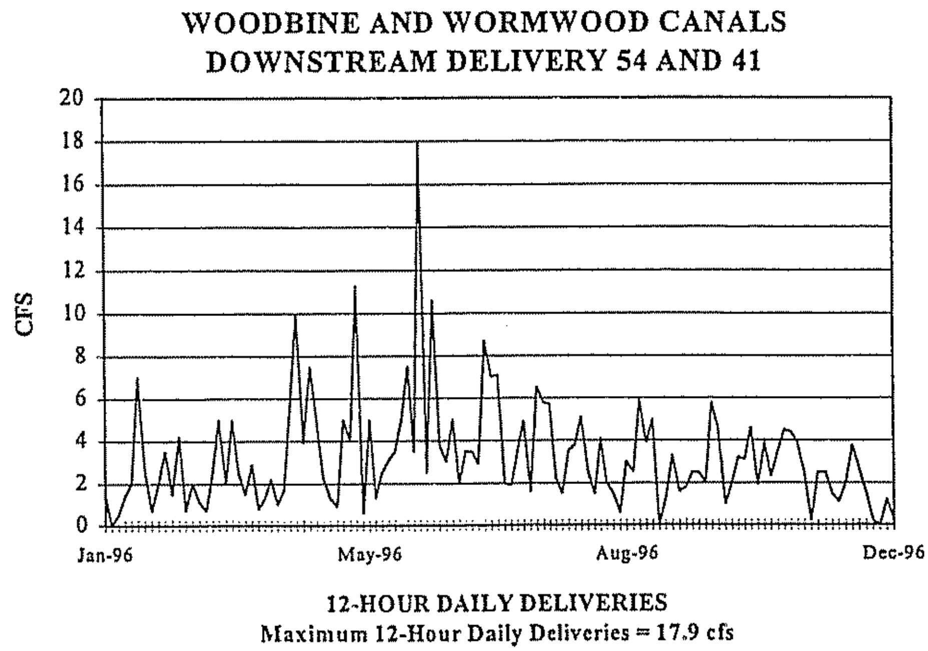


Figure 70: Woodbine And Wormwood Canals Downstream Delivery 54 and 41, 12-Hour Daily Deliveries

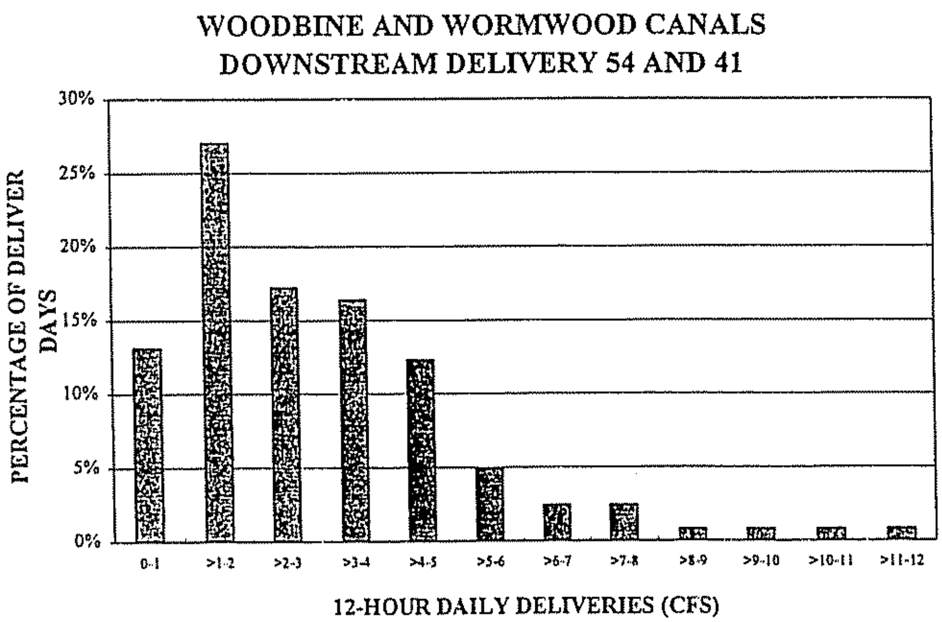


Figure 71: Woodbine And Wormwood Canals Downstream Delivery 54 and 41, 12-Hour Percentage of Delivery Days

4-17

Summary of unpublished USGS report on selenium, "Processes Controlling Selenium and Other Constituents in Irrigation Drainwater and Their Effects on Wildlife of the Salton Sea Area, Imperial County, California, 1986-90.":

ABSTRACT:

A detailed investigation of the Salton Sea area by the U.S. Department of the Interior was completed in 1990. Overall objectives of the study were to determine the extent, magnitude, and effects of contamination associated with agricultural drainage on migratory and resident birds and their habitats and to determine the sources and exposure pathways of contaminants.

Results of the study indicate that factors controlling contaminant concentrations in subsurface drainwater in the Imperial Valley are soil characteristics, hydrology, and agricultural practices. Higher contaminant concentrations commonly were associated with clayey soils, which retard the movement of irrigation water and, thus, increase evaporative concentration.

Objectives

The specific objectives that were developed for the detailed study were to:

1. Determine the source and movement of selenium and boron in the agricultural system of the Imperial Valley and the processes affecting concentrations of these elements.

2. Determine if selenium and (or) other contaminants associated with agricultural drainwater are accumulating in selected migratory bird species utilizing the Salton Sea NWR as a wintering area.

3. Determine if any drainwater contaminants have caused any averse chronic, or sublethal effects on resident birds that nest in the Salton Sea area or if there is the potential for adverse effects on reproductive success of migratory birds utilizing the Salton Sea as a wintering area.

4. Determine the bioaccumulation of selenium and (or) other drainwater contaminants in aquatic food-chain organisms important to fish and to migratory and resident birds.

5. Determine if selenium and (or) other contaminants could be bioaccumulated by transplanted freshwater clams exposed to drainwater discharged. If so, determine seasonal variation in bioaccumulation of contaminants in the transplanted clams.

(following is edited)

Colorado River water is the sole source of subsurface drainwater in the Imperial Valley. Selenium detected in subsurface drainwater throughout the Imperial Valley originates from the Colorado River. The selenium load discharged to the Salton Sea from the Alamo River is about 6.5 tons per year.

Selenium, boron, and DDE are accumulating in tissues of migratory and resident birds. Selenium in piscivorous birds, shorebirds, and Yuma clapper rail is at levels that may be affecting reproduction. Selenium bioaccumulated in Asiatic river clams.

Boron concentrations in migratory waterfowl and resident shorebirds were at levels that potentially could cause reduced growth in young.

Waterfowl and piscivorous birds may be experiencing reproductive impairment as a result of DDE contamination of food sources. Some of the highest concentrations were found in birds feeding in agricultural fields on invertebrates and small mammals.

A total of 19 organochlorine pesticides, other than DDE and its metabolites, were found in biota. Only two of these, toxaphene and hexachlorobenzene, were detected at levels above 1 microgram per gram, dry weight. No organochlorine pesticide residues above the National Academy of Sciences threshold of 1 microgram per gram to protect predatory (piscivorous) birds were found in fish.

Background

The reconnaissance study conducted by Setmire et al (1990), indicated that selenium, boron, and DDT metabolites are present in elevated levels that could cause physiological harm to resident wildlife and fish.

Elevated levels of selenium were detected in water and bottom sediment samples from Imperial Valley. The highest selenium levels were in irrigation drainage; the highest bottom sediment samples were near the mouth of the Alamo River at the Salton Sea.

It was the above information that indicated the need for a more detailed investigation in the Imperial Valley.

Purpose and Scope

This report presents the results of a detailed investigation of the Salton Sea area completed by the U.S. Department of the Interior in 1990. This was a joint effort conducted by U.S. Geological Survey and U.S. Fish and Wildlife Service. U.S.G.S. was responsible for determining the hydrologic and geochemical factors affecting concentrations of irrigation-induced contaminants, particularly selenium, and the U.S. Fish and Wildlife Service identified pathways of contaminant accumulation in biota. The results of the detailed investigation are to serve as the basis for possible future remediation efforts under the direction of the U.S. Bureau of Reclamation.

Ecology of the Salton Sea Area

...cormorants, heron,s and egrets...virtually have ceased nesting, perhaps in response to a large-scale tilapia dieoff or possibly to the effects of contaminants.

Previous Investigations

The highest selenium concentration of 300 micrograms/L was detected in a tile-drain sample, and the lowest concentration of 1 microgram/L as detected in a composite sample of Salton Sea water. The median selenium concentration in 12 samples was 19 micrograms/L. In contrast to the pattern for water, the highest bottom-sediment concentration of 3.3 mg/kg was in a composite sample from the Salton Sea.

In fish from the Salton Sea, selenium levels ranged from 3.5 to 20 micrograms/g, dry weight, for tilapia and corvina: the mean concentration, 10.5 micrograms/g dry weight, exceeds the health advisory level of 8 micrograms/g dry weight for human consumption of fish. The levels of selenium observed in samples of birds have been linked to reproductive problems at other drainwater study sites. Selenium was detected at concentrations as high as 27 and 42 micrograms/gram in livers of black-necked stilt and cormorant. However, the biological effects of selenium at these concentrations in the Salton Sea area were not documented.

Boron concentrations also were elevated in tile-drain effluent and in the Salton Sea. The median concentration in 12 water samples was 1,750 micrograms/L (Setmire and others, 1990). The highest concentration of 11,000 micrograms/L was in a composite sample from the Salton Sea. Trifolium drain 1, which discharges directly to the Salton Sea, had a boron concentration of 1,300 micrograms/L, and the Alamo River at the outlet to the Salton Sea had a concentration of 680 microgram/L. boron concentration in subsurface drainwater (eight samples) ranged from 200 to 3,400 micrograms/L.

The highest levels of boron in biota were found in plant samples. ...Samples from the three drainwater-impacted sites were higher (61 to 130 microgram/gram; mean 81.3 microgram/gram) than the control sites (40 to 48 microgram/gram; mean 43.0 microgram/gram). Smith and Anders (1989) found adverse dietary effects on waterfowl at concentrations within this range. However, the biological effects of boron at these concentrations at the Salton Sea were not observed.

Preliminary evaluation of the DDT and its metabolites in biota did not indicate substantial differences from results of other studies; however, interpretation was deferred until data from additional samples were collected in this detailed investigation.

Saiki (1990) collected a total of 21 composite samples of 4 different fish species from the Salton Sea for analysis of trace-element concentrations...concentrations of 12 elements were detected, but only selenium was elevated in comparison with levels measured in either the flesh or whole body of saltwater fishes from other studies. However, the threshold concentration in tissues for which selenium is toxic to saltwater fishes remains unknown. Boron concentrations in fish from the Salton Sea were comparable to those found in Setmire and others (1990).

In 1980, catfish collected from the Alamo and New Rivers as part of the California's Toxic Substances Monitoring Program had concentrations of total DDT in excess of National Academy of Sciences (1973) guidelines (1.0 mg/kg WW, whole fish, in freshwater systems) (McCleneghan and others, 1981). Technical DDT, endrin, and HCB (hexachlorobenzene) also were found at levels of concern in fish collected within the Imperial Valley.

(51) Matsui (1989) found significant recent decreases in the number of eggs and larvae for bairdiella and sargo. Also documented in this same study were deformities in ichthyoplankton that were attributed to unknown contaminants.

(52) Mora and others (1987) investigated the seasonal variation of body condition and organochlorines in ducks from California and Mexico in 1981-82 and found some of the highest DDT and DDE concentrations in pintails collected from the Salton Sea New.

These levels were significantly higher than levels found in the Lower Klamath NWR and were comparable to those observed at the south (high level) end of a north-to-south gradient observed in waterfowl in California by Ohlendorf and Miller (1984). In 1981, Ohlendorf and Miller (1984) found the highest levels of DDT and DDE in pintails collected from Imperial Valley--in comparison with Klamath Basin, Sacramento Valley, Sacramento/San Joaquin delta, and San Joaquin Valley. Other contaminants, such as dieldrin, PCB, and HCB, also ere found in higher concentrations in Imperial Valley waterfowl. Concentrations of polychlorinated biphenyls (PCB's) and HCB in pintails and shovelers were at levels not known to have any effect on survival or reproduction. However, further sampling was recommended for Imperial Valley to determine if DDE concentrations were at potentially harmful levels.

(52) Ohlendorf and Marois (1990) found elevated levels of DDE in great egret (geometric mean 24 ug/g WW) and black-crowned night heron eggs (geometric mean 8.62 ug/g WW) collected at Salton Sea in 1985. The mean DDE residues for night heron eggs from Salton Sea were significantly higher than those for Blair Island, Kesterson, and Volta. Seventy percent of the night heron eggs collected from Salt Sea exceeded 8 ug/g WW, which is the level known to cause decreased reproductive success in the species. Mean selenium concentration in Salton Sea night heron was higher than for other sites, but it was below concentrations associated with reproductive effects in night herons.

(53) Researchers at the Lawrence Livermore Laboratory previously found high selenium concentrations from wintering waterfowl in the Imperial Valley (Koranda and others, 1979). Mean concentrations (DW) were 15 ug/g in greenwinged teal, 15.6 ug/g in shovelers, 11.2 ug/g in pintails, and 49.5 ug/g in ruddy ducks.

On the basis of prey-item and band-recovery data, black-crowned night herons (Henny and others, 1984) and white-faced ibis (Henny and Herron, 1989) wintering in the Imperial Valley are experiencing decreased reproductive success their (more northerly breeding grounds. These studies concluded that DDE accumulation on wintering grounds was the probable source of their reproductive problems.

Development of Sampling Methodology

In the delta areas of the New and Alamo Rivers and the major drains that discharge directly to the Salton Sea, selenium is removed from the water by selenate-respiring bacteria in the shallow anaerobic sediments. These bacteria reduce the selenate in the inflowing water to elemental selenium. Uptake of the elemental selenium by benthic organisms, particularly the pileworm, then serves as the basis for a detrital food chain in the Salton Sea...This transferral of selenium between each of these trophic levels results in bioaccumulation and potentially in biomagnification.

Bioaccumulation is the accumulation of a chemical such as selenium in tissues of an organism at a concentration that is substantially higher than that in the environment in which the organisms exists (Tinsley, 1979). If tissue concentrations of a bioaccumulated constituent increase in a food chain as the constituent passes from one trophic level to another, then biomagnification is said to occur.

The biomagnification of selenium in aquatic food chains has been documented in a recent study (Lemly and Smith, 1987), but it has been questioned by others (Kay, 1984). However, it is clear that selenium concentration in animal tissue tends to reflect dietary levels, particularly when the selenium is an organic form rather then (sic) the inorganic selenite or selenate (Sharma and Singh, 1983). Selenium concentrations in aquatic ecosystems are 2 to 6 times greater in producers (phytoplankton, algae, and vascular plants) than in lower consumers (such as invertebrates and forage fish((Lemly and Smith, 1987). It also should be noted that estuarine and marine organisms usually contain higher concentrations of selenium than do freshwater or terrestrial species (Eisler, 1985). This may be an important consideration in the Salton Sea.

Biomagnification is important because it can cause top-level consumers, such as piscivorous birds, to receive toxic selenium doses in the diet even though concentrations in water may be low (lemly and Smith, 1987). Equally as important is the risk of toxicity through the detrital food pathway, which will continue despite a loss of selenium from the water column as long as contaminated sediments are present, such as in the Salton Sea.

Areal Distribution of Selected Constituents

(82) The areal distribution of the selenium concentrations (USGS samples) shown in figure 12 does not seem to indicate any strongly discernible regional pattern. An area of high selenium concentration (greater than 100 microgram/L) is located southeast of the Salton Sea NWR...Other areas of elevated levels of selenium in subsurface drainwater...are spread throughout the Imperial Valley, both along the main topographic axis of the valley and on the periphery.

Temporal Variation in Concentration of Selected Constituents

(86) Monthly subsurface drainwater samples were collected during the period August 1988 to August 1989 from 15 fields ... to determine the temporal variation in constituent concentrations. Additionally, results from the May 1988 samples were compared with the monthly monitoring data to evaluate whether the May samples are representative for the period...

...Comparison of May 1988 selenium concentrations at each of the 15 sites with the mean concentrations of the monthly samples indicates that May samples at most of the sites are reasonable representative of the general water quality at each site.

..The load values are rough estimates calculated by adding the monthly selenium concentrations times discharges; nevertheless, these load estimates provide an indication of the amount of selenium contributed by each field. The data also show that the volume of flow from the sump is the major variable influencing selenium loading. Whereas the range of selenium concentration in samples of subsurface drainwater was one order of magnitude, the range in volume of subsurface drainflow was three orders of magnitude. Overall, the highest loads occurred only during high discharges.

(88)...Se/Cl ratios that were calculated from the monthly samples also indicate that May samples are representative of irrigation drainage at the 15 sites.

(90) (paraphrased) the only two sumps that seemed to indicate possible selenium sources were S-265 and S-226. Both had very high discharges, at least for part of the year, and high selenium loadings. Se/Cl ratios were atypical as well, with little correlation between the two constituents. Se/Cl was very high for S-265, indicating a possible selenium source.

(94) ...selenium concentration is influenced by subsurface drain flow. when drain flow increases, selenium (concentration) decreases, and as drain flow decreases, selenium (concentration) increases. Usually, any such increases or decreases in drainflow are reflected by a concurrent but opposite change in selenium concentration. For some months, such as March through August, the response of concentration to discharge (site S-423, for example) appears to be lagging. Timing of reactions and (or) adsorption may be reasons for this lag.

(97) The ratios (Se/Cl for Alamo River vs East Highline Canal) indicate a small loss (about 20 percent) of selenium in comparison with chloride. In general selenium in most of the Imperial Valley...behaves fairly conservatively even as it is transported to the Salton Sea. Even a generalized comparison shows that both selenium and dissolved solids increase by a factor of about four from the East Highline Canal to the Alamo River at the outlet to the Salton Sea (2 to 8 microg/L and 686 to 2,670 mg/L, respectively). The New River does not present a valid case for examination because 40 percent of the flow at the outlet to the Salton Sea originates in Mexico and is composed mainly of domestic and municipal effluent.

(99) (paraphrased) Median selenium concentration in subsurface drainwater (May 1988 data) is 25 micrograms/L, which is the same as the discharge-weighted selenium concentration. Final selenium concentration in the Alamo River is 8 micrograms/L, requiring 74% of the water in the Alamo River to be 2 microgram/L tailwater, seepage, or other low selenium water. This compares fairly well with the computed value of 68% for 1990, combining tailwater,

leakage, and spill water.

(101) Boron concentration in the Alamo River at the outlet to the Salton Sea was 560 micrograms/L...a boron load during the 1989 water year of 457 tons...yields a dilution factor of 74 percent, the same as that for selenium. This dilution factor...also indicates that some boron gain occurs in the ditches or river. Unlike selenium, which is removed from the water of the Salton Sea, boron concentrates with evaporation to a concentration of 11,000 micrograms. Boron to chloride ratios indicate that in the movement of water through the agricultural system, some boron is lost.

(148) (This is for the northern well site, where selenium increases with depth, then decreases to less than 1 ppb at 199 ft.) The increasing presence of ammonia indicates that a reducing environment is becoming more pronounced with depth. Under reducing conditions, nitrate is converted to ammonia, and selenate can be converted to selenite, elemental selenium, or selenide, depending on the environmental conditions (soil acidity or alkalinity, pH, pE. and biota present)...According to Elrashidi and others (1987), "Under highly reducing conditions, selenides are the major inert sink of Se introduced into the environment. contamination of waters or soils by these minerals poses a minimal hazard of Se toxicity so long as their depository remains reduced."

(149) Of particular interest was the finding of elevated levels of arsenic at depth in the Imperial Valley. In reconnaissance investigation of the Salton Sea area, elevated levels of arsenic were not found in either subsurface drainwater or in bottom sediments.

(154) the understanding of the selenium-removal process has been accelerated as a result of the detection of selenium contamination at major irrigation drainwater projects--such as Kesterson National Wildlife Refuge (California), Stillwater Wildlife Management area (Nevada), Stewart Lake Waterfowl Management Areas and Ouray National wildlife Refuge in the Middle Green River basin (Utah), and Kendrick Reclamation Project area (Wyoming)--and by the research generated from concern about this contamination.

(162) The general trend of higher selenium concentrations in biota from the Salton Sea in comparison with concentrations in river/drain sites was similar to the trend found in bottom-sediment samples (Setmire and others, 1990). As reported in Eisler (1985), this trend also may be due, in part, to the finding that higher selenium concentrations are found in estuarine and marine organisms than in freshwater organisms. Limited sampling in areas not affected by agricultural drainwater, such as San Felipe and Salt Creeks, indicates the presence of significant local sources of selenium for bioaccumulation in plants and fish...

(169) Among sensitive species, whole-body selenium concentrations greater than 12 microgram/g DW may be sufficiently elevated to cause reproductive failure (Lemly and Smith, 1987). Only one sample of a freshwater species, the mosquitofish, collected from the Trifolium Drain was above this threshold. reproductive failure often is accompanied by deformities in embryos and young. However, no mosquitofish sampled during this study or the reconnaissance investigation showed any signs of deformities. Mean selenium concentration in fish from major agricultural drains, including the Trifolium Drain, of 10.8 microgram/g DW ... is well above the lowest concentrations (5-8 microg/g DW) shown to affect reproduction in warmwater fish (Lemly, 1986). It is not known if selenium in major drains has historically or is currently affecting forage-fish populations.

(169) Marine fish from the Salton Sea had whole-body selenium concentrations above the 12 microg/g DW reproductive threshold reported by Lemly and Smith (1987). However, the toxic threshold concentrations for selenium in tissues of marine fishes--such as bairdiella, orangemouth corvina, and sarge--found in the Salton Sea are unknown (While and others, 1987). Although Salton Sea fish contain elevated selenium body burdens, recent observations suggest that they still are able to successfully reproduce (Hagar and Garcia, 1988).

(170) Even though Salton Sea fish generally continue to successfully reproduce, recent data have shown significant decreases in the number of eggs and larvae of two important forage fish, bairdiella and sargo (Matsui, 1989). In addition to this reproductive decline, Matsui also documented deformities in ichthyoplankton that were attributed to ambient contamination. The malformations, that were predominantly retarded cephalic development, have been previously reported following exposure of fish to a variety of anthropogenic contaminants, including pesticides and metals (Matsui, 1989). Selenium is known to cause deformities in fish (Lemly and Smith, 1987) and is above the reproductive threshold of 12 microg/g DW in bairdiella; thus, it may be partially or fully responsible for the observed deformities.

(172) "Normal" dry weigh selenium liver concentrations for freshwater aquatic birds as reported from several field studies is between 4 and 10 microg/g. Results from this study...show that the northern shoveler, coot, and white-faced ibis all had some liver concentrations above the "normal" value, and the mean concentration in shovelers (19.1 microg/g DW) was almost twice the normal concentration.

However, the concentrations of selenium in bird livers that can be diagnostic of harm or injury are uncertain. The best information available (Heinz, 1989) indicates that when livers contain about 20 microg/g or more of selenium of a wet-weight basis, heavy exposure has taken place that should be considered a possible threat to survival. Even concentrations as low as 10 microg/g could be harmful to more sensitive species and should be of concern.

(176) Of the two waterfowl species, the northern shoveler had higher mean selenium concentrations in liver and muscle, as well as a higher range, than the ruddy duck...Comparisons with historical data collected in the Imperial Valley by Koranda and others (1979) show that selenium levels in shovelers have increased by more than 22 percent (from 15.6 to 19.1 microg/g DW). This demonstrates that northern shovelers wintering at the Salton Sea are accumulating a significant loading of selenium and that buildup in bird livers occurs rapidly after the birds arrive at the sea (7.8 days to reach 95 percent of peak concentration in mallards) and is maintained at an equilibrium in proportion to dietary selenium intake (Heinz and others, 1990)...However, the high levels accumulated at the sea probably could be eliminated (75 percent loss after 2 weeks from a high to a low selenium diet; Heinz and others, 1990). if birds migrating to the northern breeding locations consume low concentrations of selenium in their diet.

(177) (paraphrased) White-faced ibis had levels similar to Carson Lake, Nevada, but selenium concentrations did not have any effect on hatchling productivity to the age of 7-10 days (Henny and Herron, 1989). Salton Sea ibis levels were lower than Carson, so shouldn't affect reproductive effort.

(179) (paraphrased) some effect likely on some stilt eggs. "The majority of Salton Sea stilt eggs, however, had selenium values for which predicted embryotoxicity is low (less than 10 percent)."

(188) For birds feeding in the rivers and drains, mean selenium concentrations for all trophic levels are at or below the possible-threat-to-survival threshold...However, the range of concentrations for some species, especially forage fish, extends well above the threat-to-survival threshold. Birds feeding on these fish in the rivers and drains could be exposed to concentrations that affect reproduction (7 microg/g DW) and actual long-term survival (10 microg/g DW) (Heinz and others, 1990).

(190) (paraphrased) no documented problem with Boron, but possible problems with black-necked stilt hatchlings and ruddy ducks (nesting up north). Possible problems with Yuma clapper rails.

(210) ...all higher-trophic-level consumers that feed directly on lower-trophic-level organisms are bioconcentrating boron at levels known to have chronic reproductive effects on waterfowl (reduction of weight gain in ducklings and (or) reduced hatchling weight).

(211) Migratory waterfowl had the highest boron concentrations of all types of birds sampled...these birds are arriving at the sea with moderately low levels (mostly nondetectable) or boron and depart with levels known to cause adverse reproductive effects. Although residential shorebirds, such as the black-necked stilt,

may be bioaccumulating less born than are waterfowl, accumulation of born is sufficient to cause reduced weight gain in the young. Piscivorous birds feeding at the Salton sea (sic) also may be bioaccumulating boron at levels known to cause reproductive effects...In summary, boron is rapidly removed through respiration and (or) excretion from progressively higher trophic levels in both marine and freshwater food chains of the Salton sea system. This biominification, however, does not prevent potential adverse reproductive effects on waterfowl and shorebirds that feed directly on lower-trophic-level food items.

(213) DDT was introduced to the Salton Sea area as a low-cost broad-spectrum insecticide (technical DDT) and to a lesser extent as a component of dicofol products, an acaricide used heavily on cotton, formerly a major crop of the Imperial Valley. DDT was banned in the United States in 1972 (in Arizona in 1969), and in Mexico in 1983, and DDT has been regulated in dicofol during 1986-88 (now required to contain less than 0.1 percent DDT). However, recent concentrations of p,p'-DDE found in resident fauna in the Southwestern United States (including Texas, New Mexico, Arizona, and the Salton Sea area) are at levels associated with eggshell thinning and reduced reproductive success in birds...Clark and Krynitsky (1983) and White and others (1983) have suggested that recent use of DDT may have occurred in the southwest; however, Schmitt and others (1985, 1990) found no evidence of such use on the basis of fish data for the region.

(216) Clams sampled from Trifolium Drain excreted 59 percent of their p,p'-DDE during 1 year. However, during that year, p,p'-DDT concentrations in the same clams increased by 40 percent...one possible explanation is recent use of DDT.

(224) All the fish data from this investigation ...support the conclusion by Schmitt and others (1985,1990) that DDE (sic) has not been used recently in the Southwestern United States.

(238) On the basis of historical and present DDE bird residues...it is highly probably that DDE levels resulting from historical use in the Imperial Valley still may be causing reproductive impairment in resident birds.

(253) ...in this investigation, the data are indicative of potential reproductive impairment of birds of several ecological niches, including shorebirds, piscivorous birds, and birds of prey. In the Imperial and Coachella Valleys, numerous resources under Department of the Interior trusteeship are at risk, including several species with known sensitivities to DDE bioaccumulation; these include three endangered species--peregrine falcon, California brown pelican, and bald eagle--as well as osprey and herring gull...It is believed that elevated DDE concentrations in biota in the Salton Sea area are a result of past heavy use of technical DDT, in addition to use in Mexico through the 1970's and early 1980's and extensive use of dicofol through the 1980's.

(261) In summary, the groups at greatest risk are (1) the piscivorous birds, for which levels of concern are high for selenium, primarily in the Salton Sea, and for DDE, both in the Salton Sea and river and drain locations; (2) shorebirds, which feed mainly on aquatic invertebrates and for which levels of concern are variable for selenium and boron in both the Salton Sea and river and drain locations, and for DDE in the river and drain locations; (3) waterfowl, for which levels of concern are high for selenium and boron in both the Salton Sea and river and drain locations; and (4) terrestrial-feeding birds for which levels of concerns are high for DDE.

RKS strategy, for implementation after this unpublished report gets published.

1. Encourage BOR to follow up USGS/FWS study by designing program to solve potential selenium problems at Salton Sea wildlife refuge (the current USGS/FWS study was done partly..."to serve as the basis for possible future remediation efforts under the direction of the U.S. Bureau of Reclamation...").

2. (from WD) Review options for drain water quality improvement in specific areas within Imperial Valley (areas of higher selenium concentration).

3. Announce that District will do what it can to keep selenium from increasing in the future (both increases in drain water concentration, and in mass loading in Salton Sea).

4. Encourage State Board to work with IID staff, EPA, and Regional Board (and BOR if they get dragged into it) in designing a long-range plan for agriculture and the Salton Sea area.

5. And what does that long-range plan include?

   a. encourage actions that reduce the elevation of the Salton Sea. This reduces lawsuits, frees up some money for projects and studies (money that would have gone to lawsuits), and frees up some land for projects.

   b. shift conservation projects under current program toward anything that reduces tile water (possibly drip)

   c. require that one of the following two options happen:

      i. no more conservation until the master plan is developed, and signed off on by IID, MWD, CVWD, EPA, SWRCB, RWQCB, and BOR; or,

      ii. any future water conservation agreement provide a stopping mechanism if levels of selenium, or selenium induced impacts to wildlife, get higher than agreed upon limits.

   d. use existing and future money in the IID/MWD "set aside fund" or money obtained through future water conservation to fund staff and projects.

   e. encourage the State and Federal government to design suitable mitigation banks for Imperial Valley projects, including the small projects being conducted between IID and FWS at the Salton Sea refuge now.

   f. encourage the Resources Agency of California to provide